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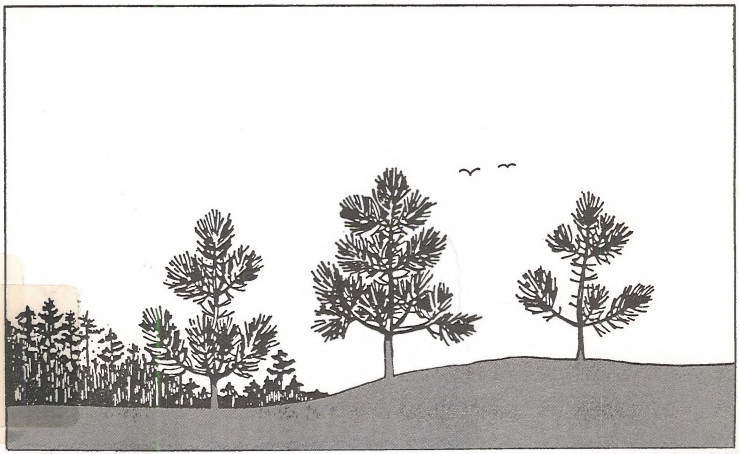
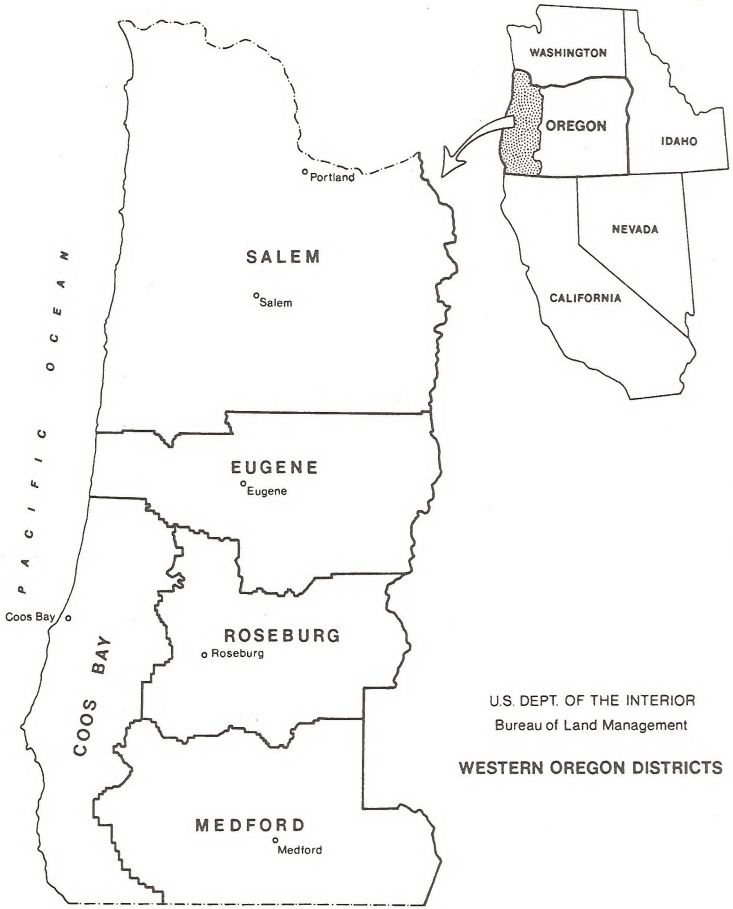
Supplement

Oregon State Office — February 1986

Supplement to the Western Oregon Program-Management of Competing Vegetation

Draft Environmental Impact Statement





U.S. DEPT. OF THE INTERIOR
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WESTERN OREGON DISTRICTS

IN REPLY REFER TO:

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

OREGON STATE OFFICE
P.O. Box 2965 (825 NE Multnomah Street)
Portland, Oregon 97208

Enclosed for your review and comment is the Supplement to the Draft Environmental Impact Statement (SEIS) for the Western Oregon Program - Management of Competing Vegetation. This statement presents a risk assessment and worst-case analysis of impacts on human health from using herbicides as proposed in the Draft EIS (June 1983). In using this analysis, readers should keep in mind that the EIS (draft, supplement or final) is not a decision document. A Record of Decision will follow the Final EIS.

The human health risk assessment was prepared for the USDI Bureau of Land Management and USDA Forest Service by a private consulting firm, Labat-Anderson Incorporated of Arlington, Virginia.

Comments concerning the adequacy of this statement will be considered in preparation of the Final Environmental Impact Satement. A 60-day comment period has been established for this supplement. The comment period will close on April 30, 1986.

Please send your comments on this supplement to:

Oregon State Director
Bureau of Land Management (935)
c/o R. Gregg Simmons
P.O. Box 2965
Portland, Oregon 97208

Comments received after the close of the comment period will be considered in the decision process, even though they may be too late to be specifically addressed in the final environmental impact statement.

A limited number of copies of the Draft EIS are available upon request. Please contact the nearest BLM District Office or the State Office in Portland.

Sincerely,

William D. Leavell

State Director, Oregon and Washington

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Supplement to the Western Oregon Program-Management of Competing Vegetation

Draft Environmental Impact Statement

Prepared by

U.S. Department of the Interior
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February 1986

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Proposed Western Oregon Program for the Management of Competing Vegetation

Supplement to the Draft (X) Final ()
Environmental Impact Statement
U.S. Department of the Interior, Bureau of Land Management

1. Type of Action: Administrative (X) Legislative ()

2. Abstract: The Draft EIS describes and analyzes the environmental impacts of implementing the proposed western Oregon program for the management of competing vegetation. To achieve a high level of timber production on lands in the timber base, harvested lands must be reforested promptly. Control of competing vegetation is necessary to achieve this goal. The alternatives analyzed include: 1) The Proposed Action, 2) Maximum Herbicides, 3) No Burning, 4) Labor-Intensive, 5) Restricted Aerial, 6) No Aerial, 7) No Herbicides and 8) No Action. Alternative 1 (Proposed Action) is the preferred alternative. Significant environmental impacts of the preferred alternative include reduced wildlife habitat diversity, smoke intrusion problems and increased jobs.

3. In response to public comment on the Draft EIS and Judicial opinion, BLM, in cooperation with the U.S. Forest Service, has conducted a Risk Analysis of the impacts to human health from using herbicides. The risk assessment which is presented as Appendix L, was prepared for the Forest Service and BLM by Labat-Anderson Incorporated located in Arlington, Virginia.

4. This Supplemental Statement is expected to be filed with the Environmental Protection Agency (EPA) and made available to the public on February 28, 1986. The comment period will close on April 30, 1986.

5. For further information contact:

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Portland, Oregon 97208

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Introduction

The Draft Environmental Impact Statement (DEIS) for the Western Oregon Program - Management of Competing Vegetation was released for public review and comment in June 1983. That DEIS discussed eight alternatives and proposed adopting an integrated pest management (IMP) program for management of competing vegetation which includes the use of 14 herbicides. Although the risk analysis (Appendix L) addresses 16 herbicides, it does not cover three herbicides proposed for use in the DEIS. These herbicides are: ammonium sulfamate (ammate), diquat, and MSMA. Prior to using these three herbicides on BLM-administered lands, a like risk analysis would be conducted (individually or collectively). The following summary plus the new Appendixes L (Risk Analysis) and M (Toxicity Research Costs) constitute a Supplement to BLM's Draft EIS (1983).

The Worst-Case Analysis Requirement

The "worst-case analysis" regulation, 40 C.F.R. § 1502.22, was promulgated in 1979 by the Council on Environmental Quality (Council or CEQ). The regulation is one of many implementing the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. § 4321 et seq. (1976) and it sets out the formal procedure an agency must follow when confronted with gaps in relevant information or scientific uncertainty about significant, adverse effects on the environment from a major federal action. The regulation requires an agency to make known when it is confronted with gaps in relevant information or scientific uncertainty. 40 C.F.R. § 1502.22. An agency then must determine if the missing information is essential to a reasoned choice among the alternatives. When the missing information is material to the decision, an agency ordinarily must obtain the information and include it in an environmental impact statement (EIS). 40 C.F.R. § 1502.22(a). If the means for obtaining the missing information are "beyond the state of the art," or alternatively if the costs of obtaining it are "exorbitant," an agency must then prepare a worst-case analysis, 40 C.F.R. § 1502.22(b). In this analysis, an agency must "weigh the need for the action against the risk and severity of possible adverse impacts were the action to proceed in the face of uncertainty" ID. An agency also is to indicate "the probability or improbability of its (the worst-case's) occurrence." Id.

On the basis of the discord surrounding the interpretation of study results (Hansen study) and EPA's decision to undertake additional study, the courts have concluded that scientific uncertainty exists about 2,4-D's carcinogenic effect. See Save Our EcoSystems v Clark, F.2d (9th Cir. 1984); Southern Oregon Citizens Against Toxic Sprays v. Clark, 720 F.2d 1475 (9th Cir. 1983); cert. denied, _____ U.S. _____, 105 s.ct. 446, 83 L Ed. 2d 372 (1984). The disagreement among experts about picloram's carcinogenic effect is essentially the same as that surrounding 2,4-D. Hence, given existing judicial opinion, the agency is constrained to find that there is scientific uncertainty about asulam's and glyphosate's carcinogenic effects. Regarding resolution of the scientific uncertainty surrounding 2,4-D's, picloram's, asulam's and glyphosate's carcinogencity, as indicated below, the costs of obtaining additional information to resolve that dispute are exorbitant (Appendix M). Accordingly, the BLM must prepare a worst-case analysis as input to the decision making process regarding the use of 2,4-D, picloram, asulam, and glyphosate.

Cost of Additional Research

BLM does not have the staff, expertise, or funds to fill the existing data gaps, and the time required to perform these studies would seriously delay the execution of an effective vegetation management program. To fill all the data gaps pertaining to the carcinogencity of picloram, asulam, glyphosate, and 2,4-D could require a total investment between $3.5 and 4.2 million, and 3 to 5 years of study per chemical. These figures are derived from cost estimates submitted to the EPA from Cenatur Associates, Inc. (1982), which are summarized in Table M-1 (Appendix M). The time estimates are are based on historical data for toxicological research. EPA (1980) highlighted 2,4-D data gaps in the areas of oncogenicity, reproductive effects, and metabolism in animals. Additional research on chronic toxicity, teratogenicity, etc. could also be required, further adding to the costs. These costs are considered exorbitant.

Risk Analysis Overview

This analysis (Appendix L) assesses the risk to human health of using 16 different herbicides for vegetation management on Bureau of Land Management (BLM) lands in western Oregon and on Forest Service lands in Washington and Oregon. The 16 herbicides are amitrole, asulam, atrazine, bromacil, 2,4-D, 2,4-DP, dalapon, dicamba, diuron, fosamine, glyphosate, hexazinone, picloram, simazine, tebuthiuron, and triclopyr. All of these herbicides except amitrole, bromacil, 2,4-DP, simagine, and tebuthiuron have been proposed for use on the BLM lands.

This risk assessment is intended to be a supplement to the BLM Draft EIS entitled Western Oregon Program: Management of Competing Vegetation (1983) and the Forest Service

Environmental Impact Statement (EIS) entitled Methods of Managing Competing Vegetation: A Programmatic Environmental Impact Statement (1981). It has been prepared pursuant to the requirements of the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1502.22).

Two human populations were considered at risk from herbicide application operations: workers and the general public. The workers included personnel, such as mixer/loaders and backpack sprayers, who are directly involved in treatment operations. The public included forest visitors and nearby residents who may be directly exposed to herbicide drift, to vegetation with herbicide residues, or to an accidental spraying. The public may be indirectly exposed by eating food or drinking water containing herbicide residues.

In preparing this risk assessment a number of uncertainties and data gaps were identified, including worker field studies on 11 of the herbicides; information on exposure of the public to the 16 herbicides; field data on herbicide residue levels in plants and animals; mutagenicity studies for bromacil, dalapon, and diuron; the potential for amitrole, asulam, bromacil, 2,4-D, 2,4-DP, picloram, and glyphosate to cause cancer; and toxicity information on the synergistic effects from exposure to more than one herbicide.

The information that is lacking or uncertain is important in deciding the best alternative for vegetation management. However, the overall cost of conducting the studies to fill the data gaps is considered exorbitant with respect to the limited funds available to the Forest Service and BLM. In addition, the time needed to perform and evaluate most of these tests is more than 2 years. Many of the necessary toxicological studies have already been requested by EPA, and the results of these studies will be considered when they become available. In addition, EPA and the Forest Service and BLM have ongoing or proposed research and monitoring programs to examine the effects of herbicide treatment, and these results will be considered as they become available.

The large body of data that does exist for many of the herbicides, apart from the data gaps and areas of uncertainty, was used to analyze the environmental behavior and toxicity of the herbicides. Where data gaps or uncertainty existed, a worst-case analysis was conducted.

Summary of Risk Assessment for BLM's Western Oregon Program

The following is a summary of the information in the Risk Analysis (Appendix L) as it applies to BLM's proposed Western Oregon Program-Management of Competing Vegetation (DEIS, 1983). Tables 1 and 2 portray BLM's typical annual herbicide program proposed for Western Oregon.

Risk Assessment Components

This risk assessment employed the three principal analytical elements to characterize the potential adverse health effects of human exposures to the 11 herbicides: hazard analysis, exposure analysis, and risk analysis.

In the hazard analysis, information was gathered to determine the toxic properties of each herbicide. The toxicity reference levels used to judge the human hazard of each herbicide used in the risk analysis were derived from laboratory animal studies.

In the exposure analysis, herbicide application scenarios were used to estimate single and multiple human doses that would result from exposures in routine operations and as a result of accidents. The number and characteristics of persons in exposed populations were also considered.

In the risk analysis, potential adverse health effects to individuals under the specified conditions of exposure were analyzed by comparing the toxicity levels determined in the hazard analysis with the dose estimates made in the exposure analysis. A risk judgement was based on this comparison in terms of a margin-of-safety and on an analysis of the probability that the estimated doses would actually occur.

Hazard Analysis

The toxicity reference levels for acute effects, the reference levels for systemic and reproductive effects, and the cancer potencies of the herbicides are summarized in Table 3. All of the cancer potency values have an expected value of zero

Table 1. Typical Annual Program For Herbicide Use Proposed for Western Oregon

Projects	BLM Acres
Silviculture: site preparation and conifer release	38,800 - 44,100
Right-of-way maintenance[1]	1,900
Noxious weed control	300

[1]Includes road and highway, railroad, and power and other utility line rights-of-way (ROW).

Table 2. Herbicide Application Rates (lb/acre)[1] Used by Application Method

	Aerial		Backpack		Truck-Tractor	
	Typical	High	Typical	High	Typical	High
Asulam	2.40	3.34	1.20	3.34	2.40	5.00
Atrazine	3.75	4.00	3.00	4.00	3.00	8.50
2,4-D	2.50	4.00	2.00	4.00	2.50	4.10
Dalapon	4.00	10.00	4.00	12.00	4.00	10.00
Dicamba	1.00	4.00	0.50	4.00	1.00	3.60
Diuron	0.00	0.00	4.00	6.00	4.00	16.00
Fosamine	3.00	12.00	3.00	11.50	4.00	10.70
Glyphosate	2.00	5.00	1.50	5.00	2.00	5.00
Hexazionone	2.50	3.00	1.12	3.00	2.50	6.00
Picloram	1.00	5.00	1.00	4.00	1.00	2.00
Triclopyr	2.00	4.00	3.00	8.00	2.00	8.00

[1]Rates are pounds of active ingredient (a.i.) per acre. Figures represent the typical and high actual rates by activity during 1982 and 1983. A 0.00 rate indicates that a compound has not been used for the activity or method of applications.

Per acre application rates for hand application (hack and squirt or stump treatment) are not meaningful and therefore not shown.

Table 3. Toxicity and Cancer Potency of Herbicides

Herbicide	Rat LD_{50}[1] (mg/kg)	Systemic NOEL[2] (mg/kg/day)	Reproductive/ Teratogenic NOEL (mg/kg/day)	Cancer Potency (per mg/kg/day)
Asulam	4,000	50.0	50.0	0.02
Atrazine	1,869	3.7	100.0	0
2,4-D	375	1.0	25.0	0.005
Dalapon	7,577	15.0	300.0	0
Dicamba	757	25.0	2.5	0
Diuron	3,750	0.625	6.2	
			5	0
Fosamine	24,40			
	0	25.0	750.0	0
Glyphosate	4,320	30.0	10.0	0.000024
Hexazinone	1,690	10.0	125.0	0
Picloram	8,200	7.0	50.0	0.00057
Triclopyr	630	2.5	10.0	0

[1]LD_{50}: The dosage of toxicant (expressed in milligrams of toxicant per kilogram of animal body weight) required to kill 50 percent of the animals in test population when given orally.

[2]No Observed Effect Level (NOEL): (1) the lowest dose of a substance by any route other than inhalation that has been found by experiment with animals to have no toxic effect on the animals or (2) the lowest concentration of a substance in air that has been found by experiment with animals to have no toxic effect on the animals exposed for a defined time.

Table 4. Summary of Mutagenicity and Carcinogenicity of Herbicides

Herbicide	Mutagenicity	Carcinogenicity
Asulam	Nonmutagenic in 3 assays (EPA, 1984b)	Oncogenic in 1 study (EPA, 1985d). Nononcogenic at HDT in 2 studies (EPA, 1984b)
Atrazine	Mutagenic in 15/33 assays (EPA, 1984c)	Nononcogenic in 2 studies (EPA, 1984c)
2,4-D	Nonmutagenic in 23/31 assays (USDA, 1984)	Nononcogenic in 2 studies (EPA, 1984e) Scientific Uncertainty (Rueber, 1979, as cited in BLM, 1985)
Dalapon	No studies reported (EPA, 1984g; USDA, 1984)	Nononcogenic in 2 studies (USDA, 1984);
Dicamba (USDA, 1984)	Nonmutagenic in 6/8 assays 2 studies (EPA, 1984h);	Nononcogenic in Studies not adequate according to EPA (EPA, 1958d).
Diuron	No studies (EPA, 1984i; USDA, 1984)	Nononcogenic in 2 studied (EPA, 1984i). Studies not adequate according to EPA (EPA, 1985d)
Fosamine	Nonmutagenic in 4/5 assays (USDA, 1984)	Nononcogenic in 3 sub-chronic studies (EPA, 1984j; USDA, 1984)
Glyphosate	Nonmutagenic in 8 assays (EPA, 1984k)	Nononcogenic in 1 study at HDT (EPA, 1984k). Possibility of weak oncogenic effect in mouse study (EPA, 1985b)
Hexazinone	Nonmutagenic in 5/6 test systems (USDA, 1984)	Nononcogenic in 2 studies (EPA, 1984l)
Picloram	Nonmutagenic in 9/10 assays (USDA, 1984)	Nononcogenic in 3/5 studies (EPA, 1984m; Mullison, 1985)
Triclopyr	Nonmutagenic in 4/5 bacterial and cytogenetic assays (USDA, 1984; EPA, 1985d)	Nononcogenic in 3 studies (USDA, 1984)

except for asulam, 2,4-D, glyphosate, and picloram. The results of mutagenicity and cancer testing on the 11 herbicides are summarized in Table 4.

Exposure Analysis

Doses to Workers in Routine Operations

Worker doses were estimated by extrapolating from dose levels found in field studies of actual herbicide treatment operations that used amitrole, 2,4-D, 2,4-DP, picloram, and dicamba. Where no field data existed for a particular application method, and for the 11 herbicides not tested in field studies, extrapolation was done from the 2,4-D studies. The worker categories and scenarios used for estimating routine-realistic worker doses were the following:

1. Doses to pilots, mixer-loaders, supervisors, and observers in a helicopter treatment of four 40-acre silviculture sites.

2. Doses to applicators, mixer-loaders, and applicator/mixer-loaders in truck spraying of 12 acres (33 feet wide by 3 miles long) of roadway right-of-way.

3. Backpack applicator doses in backpack spraying of a 6-acre facilities maintenance site by 2 applicators for 6 hours.

4. Doses to applicators using hack-and-squirt and injection bar methods in hand treatment of 3 acres by 2 applicators for 6 hours.

The categories and scenarios used for estimating worst-case routine worker doses were the following:

1. Doses to pilots, mixer-loaders, supervisors, and observers in fixed-wing spraying of a 400-acre site for range improvement.

2. Doses to applicators, mixer-loaders, and applicator/mixer-loaders in truck spraying of 40 acres of transmission line right-of-way.

3. Backpack applicator doses in backpack spraying of a 60-acre conifer release site by 14 applicators for 9 hours.

4. Doses to applicators using hack and squirt and injection bar methods in hand treatment of 9 acres by 4 applicators for 9 hours.

Herbicide doses to workers involved in routine operations were estimated using eight application scenarios: four to predict realistic doses to workers in routine operations (routine-realistic doses) and four to predict worst-case doses to workers in routine operations (routine-worst case doses). For each scenario, worker categories were chosen to represent the normal range of work activities in terms of potential herbicide exposure. The realistic dose is an estimate of the average dose a worker would receive on a typical day in normal treatment operations. The worst-case dose is based on 95-percent of the upper limit of the range of possible doses rather than the average, and assumes the largest treatment unit size, and the highest application rate. The probability of these routine-worst case doses occurring is less than 1 person out of 10,000 individuals exposed via the scenarios. No category of workers in the field is expected to experience greater exposure than the types of workers considered in this analysis.

Doses to the Public from Routine Operations

Doses to members of the public as a result of routine operations were estimated using the first three routine-realistic and the first three routine-worst case scenarios used to derive the worker doses. The hand application scenarios were excluded because no drift is involved and the chance of any other type of public contact with the herbicides in these operations is negligible.

Because no field studies existed on actual doses to the public comparable to those used for estimating worker doses, public doses were estimated by modeling the transport and fate of the applied herbicides. The residue levels on human skin, on plants and animals, and on the surfaces of water bodies were estimated using data from field studies of the drift and surface deposition of herbicides in aerial and ground-based spray operations.

Nine possible routes of exposure to the public were analyzed. Dermal doses from deposition of herbicide on their skin (from off-site drift) and from contacting vegetation with drift residues were estimated. Doses from drinking water with residues and from eating berries, deer meat, game bird meat, garden vegetables, and fish containing herbicide residues were also calculated. Doses to five "example" people--hikers, berry pickers, hunters, fishermen, and nearby residents--who were assumed to receive doses simultaneously through several exposure routes were calculated. The probability of any member of the public getting a routine-worst case dose is less than 1 individual out of 100,000 exposed via the scenario.

Doses to Workers and the Public from Accidents

The following accidental-worst case scenarios were used to estimate the worst case doses that would result:

1. Accidental Spraying. Members of the public are accidently sprayed with herbicide because they are beneath a spray aircraft or too close to a truck or backpack applicator (this dose would also apply to workers) or they receive doses through the same exposure routes used in the routine scenarios but all items that they eat, drink, or brush up against receive herbicide at the full per acre application rate, not just drift residues.

2. Spills. Members of the public receive herbicide exposure via drinking water when a helicopter or batch truck herbicide load is dumped or when a container of herbicide concentrate breaks open and spills into a drinking water supply. Workers spill concentrate or prepared spray mixture on their skin during mixing, loading, or spraying operations; or are doused when a transfer hose breaks.

Risk Analysis

Risks to humans exposed to the 11 herbicides are quantified by comparing the doses estimated in the exposure scenarios described above with the toxicity reference levels listed in Table 3. For threshold effects, the doses were compared to NOEL's determined in the most sensitive animal test species. A margin-of-safety (MOS), the animal NOEL divided by the estimated human dose, was calculated to relate the doses and effects seen in animals to estimated doses and possible effects in humans. For example, an animal NOEL of 20 mg/day divided by an estimated human dose of 0.2 mg/kg gives an MOS of 100. The larger the margin-of-safety (the smaller the estimated human dose compared to the animal NOEL), the lower the risk to human health.

When an estimated dose exceeds a NOEL the ratio is reversed to indicate how high the estimated dose is above the laboratory toxicity level and a minus sign is attached. The result is no longer termed a margin of safety but is called simply a negative ratio. A negative ratio does not necessarily lead to the conclusion that there will be human toxic effects because all of the NOEL's used in this risk analysis are based on (or take into account) long-term multiple exposures during animal studies. This applies particularly to doses that are not likely to occur more than once, such as those to the public.

Doses that exceed the NOEL are also compared to the herbicide's acute LD 50 to evaluate the risk of fatal effects.

Systemic effects are evaluated based on the lowest systemic NOEL found in a 2-year feeding study of dogs, rats, or mice. Where subchronic NOEL's were lower than those of chronic studies, the subchronic NOEL's were used. Reproductive effects are evaluated based on the lowest maternal, fetotoxic, or teratogenic NOEL found in a 3-generation reproductive study or in a teratology study.

A worst-case analysis of cancer risk is conducted for the herbicides asulam, picloram, 2,4-D, and glyphosate by comparing estimates of lifetime dose with cancer potency estimates derived in the Hazard Analysis. A worst-case analysis is also conducted for those herbicides that have positive mutagenicity tests or those for which no data is available. The risk of these herbicides causing mutations is qualitative rather than quantitative, with a statement of the probable risk based on the available evidence of mutagencity and carcinogenicity.

Risk of General Systemic and Reproductive Effects

Table 5 summarizes the margin-of-safety results for the public for the 11 herbicides under both the routine-realistic and routine-worst case exposure scenarios.

Public Risk from Routine-Realistic Doses

Table 5 shows that there are large margins-of-safety (greater than 150) for every category of public exposure—even cumulative exposures—under the routine-realistic scenario for asulam, atrazine, 2,4-D, dalapon, dicamba, diuron, fosamine, glyphosate, hexazinone, picloram, and triclopyr. Because no member of the public should be exposed the majority of the time, these large margins of safety mean that the public should suffer no adverse effects. This is true for all individuals including pregnant women and sensitive individuals.

Table 5. Lowest Margins of Safety for the General Public Under the Routine Scenarios

Herbicide	Routine-Realistic Scenarios	Routine-Worst Case[1] Scenarios
Asulam	Greater than 6,600 in all situations	All situations greater than 700.
Atrazine	Greater than 310 in all situations	All situations greater than 50 except for berrypickers (44), for the 400-acre aerial application.
2,4-D	Greater than 150 in all situations	All right-of-way and backpack spraying MOS's are greater than 380. All aerial MOS's are greater than 10 with the following situations having MOS's of 10 to 50: vegetation contact by picker (38), eating vegetables (48), hiker (43), berrypicker (17), hunter (32), fisherman (36) and resident (23).
Dalapon	Greater than 1,100 in all situations	All situations greater than 70.
Dicamba	Greater than 1000 in all situations	All situations greater than 100 except for berrypickers (46), hunters (84), fishermen (94), and residents (60) for 400-acre aerial application.
Diuron	Greater than 180 in all situations	Greater than 75 in all situations.
Fosamine	All greater than 2,600.	All 99 or greater.
Glyphosate	All greater than 1,500.	All 95 or greater.
Hexazinone	All greater than 1,200.	All greater than 150.
Picloram	All greater than 3,400.	All greater than 150.
Triclopyr	All greater than 390.	All situations greater than 50 greater except for vegetation contact by hiker (29), berrypicker (15), hunter (32), fisherman (36), and resident (35) for 400-acre aerial application.

[1]A margin-of-safety of 50 was chosen as the cutoff to report specific values in this table for ease of comparison. It was not intended to indicate what would be considered low or high risk.

The members of the public at greatest risk are the nearby resident and the berrypicker. Exposure routes leading to least risk are direct dermal exposure to spray drift and eating animals or fish that have drift residues. Persons at least risk are the hunter, hiker, and fisherman. These relationships hold for all 11 herbicides.

Although the routine-realistic scenarios represent what can happen under routine operations, the probability of people receiving doses as high as those projected is quite low because there are no residents, hikers, fishermen, or berrypickers in the vicinity of the vast majority of treatment units. Moreover, these scenarios use a number of conservative assumptions that tend to overestimate what is expected in the majority of operations.

Public Risk from Routine-Worst Case Doses

The routine-worst case scenarios were intended to indicate the upper limit for public exposure to herbicide applications in the Pacific Northwest. The low probability of each assumption, which would apply to all of the events that led to the exposures described in Table 5, must be emphasized. It is extremely unlikely that anyone would receive a dose as high as those estimated here.

Table 5 indicates that most margins of safety under the routine-worst case scenario are greater than 50 except those for 2,4-D, and triclopyr. Under these extreme assumptions, risk to individuals is very low except for people who receive multiple exposures from a 400-acre fixed wing application scenerio. Margins-of-safety calculated for combined routes of exposure to 2,4-D and triclopyr were all within the range of 10 to 50 for the worst-case aerial application scenario. Chronic doses of 2,4-D, as predicted by this analysis, could affect the peripheral nervous system which, in most cases, would be a reversible effect. People who repeatedly receive triclopyr doses as high as those predicted here could experience kidney problems. Because the margins-of-safety were computed by comparing acute exposures with chronic no-effect levels, the risk of occurrence of these effects can be considered relatively low.

The margins-of-safety computed for the 400-acre aerial spray scenario indicate that sensitive individuals could suffer some acute toxic effects from the worst-case exposures doses for atrazine, 2,4-D, dicamba, and triclopyr. For atrazine, all margins of safety are greater than 50 except for a berrypicker who is dermally exposed for 4 hours, eats 0.9 pounds of berries and drinks a liter of water containing herbicide residues at the highest possible level. This person, as well as any people who receive multiple exposures to dicamba could experience some systemic effects. However, that is unlikely because these are one-time doses and are all more than 10,000 times lower than the LD 50 . It should be noted that the systemic NOEL for atrazine is based on weight loss in dogs. Sensitive individuals could become ill and possibly experience stomach problems. Any toxic effects resulting from these routine-worst case doses, however, should be limited.

The probability of someone receiving a dose as high as those predicted under the routine-worst case scenarios is negligible because these scenarios assume that a number of unlikely events occur simultaneously. The probability of someone receiving a dose as high as is posited here is on the order of 1 out of 1 million people exposed. Historical records indicate that the probability of the scenario events occurring simultaneously is even lower.

Public Risk from Accidental Doses

Table 6 summarizes the risk to the public from direct exposure to aerial applications or from eating food or drinking water that has been directly hit at the highest application rate. The relatively low margins-of-safety for atrazine, 2,4-D, diuron, and triclopyr indicate that people exposed to a direct aerial application or exposed to items that received the highest application could experience some toxic effects. The extent of effects would depend upon their duration of exposure and any precautionary measures that were taken. For example, people gathering a bushel of berries from a spray area and not washing them but freezing them and then eating them every day for a month, would probably feel quite ill. However, if those people washed the berries before eating them, the doses would drop (and thus increase the margins-of-safety) substantially.

These are one-time, rather than repeat or chronic, exposures and the comparison of these doses with the acute LD 50 s shows that no one is at risk of fatal effects.

Worker Risk from Routine-Realistic Doses

In the routine-realistic scenarios, all categories of workers applying asulam or picloram have MOS values greater than 100. This indicates that even workers continually exposed to these herbicides should suffer no ill effects. Backpack sprayers would be at greatest risk based on comparisons of estimated doses with systemic and reproductive NOELs. Except for those using asulam and picloram, all backpack sprayers had MOS values less than 100. Doses of atrazine, 2,4-D, and triclopyr to backpack sprayers gave MOS values less than

Table 6. Margins-of-Safety Less Than 10 for the General Public in the Accidental-Worst Case Scenarios

Herbicide	MOS Values Less Than 10	
	Full Application Rate	Spill
Asulam	None less than 10 for either scenario.	
Atrazine	Vegetation contact by picker, hiker, berrypicker, hunter, fisherman, and resident.	Truck spill into pond.
2,4-D	Vegetation contact by hiker, berry picker, hunter, fisherman, and resident.	Truck spill into pond.
Dalapon	Vegetation contact by the berrypicker.	Truck spill into pond.
Dicamba	Cumulative exposure of the berrypicker.	Truck spill into pond.
Diuron	In eight cases the doses exceed the NOEL. All margins-of-safety, except hiker vegetation contact and person eating deer, are less than 10.	Truck spill into pond.
Fosamine	None less than 10 for either scenario	
Glyphosate	None less than 10 for either scenario.	
Hexazinone	Vegetation contact by the berrypicker.	Truck spill into pond.
Picloram	None less than 10.	Truck spill into pond.
Triclopyr	Vegetation contact by the berrypicker, hiker, hunter, fisherman, and the resident.	Truck spill into pond.

10; and in the case of diuron, the dose exceeds the NOEL. This means that unprotected sensitive workers could experience some toxic effects from routinely applying these herbicides in certain situations. The doses and margins-of-safety are based on 6 hours per day of exposure. Any reduction in the time of exposure would reduce the dose and increase the margin-of-safety proportionally.

Diuron appears to be the herbicide presenting the greatest risk from repeated exposures to other types of workers. Backpack sprayers using diuron in the routine-realistic scenario receive a dose that is less than the systemic NOEL. Diuron systemic MOS values for hack-and-squirt applicators are less than 10 in the routine-realistic case.

2,4-D presents the next highest long-term risk. Backpack sprayers using 2,4-D in the routine-realistic scenarios receive doses that have systemic margins-of-safety less than 10. Pilots, mixer/loaders, and both types of hand applicators have MOS values less than 50.

Triclopyr has at least 2 margins-of-safety for workers (including those for backpack sprayers) that are less than 100.

Protective clothing can substantially reduce worker exposure by 27 to 99 percent as shown in a number of relevant field studies. The margins-of-safety calculated for routine-realistic and routine-worst case exposure to workers illustrate the effect of protective clothing on the doses received by the workers involved in pesticide application.

Worker Risk from Routine-Worst Case Doses

Backpack sprayers using diuron, 2,4-D, or triclopyr in the routine-worst case scenario receive doses that exceed their respective systemic NOELs. In addition, doses calculated for truck applicators and hack-and-squirt applicators using diuron exceed the systemic NOEL. Margins-of-safety for reproductive NOELs are much higher. No applicator dose exceeds the reproductive NOEL for any herbicide in any situation.

All categories of workers, except the aerial supervisor and observer, have margins-of-safety less than 10 for at least one of the herbicides. Picloram and asulam are the only herbicides that always have margins of safety greater than 20 for all categories of workers.

The vast majority of the time workers will be receiving doses less than those predicted in the routine-worst case scenario. The probability of workers receiving repeated daily doses as high as predicted here is less than 1 in 1,000.

For workers who spill a pint of concentrate or spray mix on their skin there is some certainty that, with the exception of picloram, they could experience acute toxic effects, providing they do not wash it off. The modeling used in the analysis assumed that a certain percentage of the herbicide penetrates the skin instantaneously. In reality, the penetration through skin occurs over a period of many hours. In the case of a spill of a pint of concentrate, many of the doses approach the LD 50 . This represents a clear risk of severe toxic effects providing the herbicide is not washed off. There is some possibility that the damage caused by such a large acute dose could cause long-term damage to vital organs. There have also been rare instances in which limited exposure to 2,4-D caused permanent nerve damage. The dose and the risk is much greater for spills of concentrate than it is for spills of spray mix but, again, it is highly unlikely that workers would allow the chemical to penetrate their skin for any period of time.

Risk to Workers and the Public from Large Spill Accidents

Table 7 summarizes the margins-of-safety for people drinking one quart of water containing herbicide residues due to accidental spills from a helicopter or truck. Most drinking water reservoirs would dilute the herbicide below no-observable-effect levels in a relatively short period of time. Both BLM and the Forest Service, in addition to EPA and the states, have procedures to minimize the risk to human health should a spill of this magnitude occur in or on the vicinity of a drinking water reservoir. Therefore, after the spill has been diluted, the risk to members of the public would be much lower.

Spills into a small, stagnant pond would result in significantly higher doses and, in the event of a truck spill of 1,000 gallons there provide a risk of chronic effects providing members of the public continued to drink from it. Both the Forest Service and BLM have detailed spill prevention and clean up procedures that would attempt to ensure that no member of the public was chronically exposed to a spill of this magnitude.

Cancer Risk

(Note: Cancer risks computed for the sum of the BLM and Forest Service programs are portrayed in this section.)

Cancer risks for asulam, 2,4-D, glyphosate, and picloram were calculated based on a variety of conservative assumptions that are likely to overestimate the risks. These assumptions are described in Section 5 of this risk assessment (Appendix L).

Table 7. Margins-of-Safety for People Drinking One Quart of Water Containing Herbicide Residues (Due to Accidental Spills) Compared to the Systemic NOEL

Herbicide	Helicopter[1]		Truck[2]	
	Into a Reservoir	Into a Pond	Into a Reservoir	Into a Pond
Asulam	26,000	810	2,600	81
Atrazine	1,600	50	160	5.0
2,4-D	430	14	43	1.4
Dalapon	2,600	81	260	8.1
Dicamba	540	17	54	1.7
Diuron	[3]	[3]	34	1.1
Fosamine	3,600	110	360	11
Glyphosate	10,000	330	1,000	33
Hexazinone	5,800	180	580	18
Picloram	2,400	76	240	7.6
Triclopyr	540	17	54	1.7

[1]Assumes a helicopter carrying 100 gallons of spray mix, jettisoning the entire load into a 16-acre by 8-foot-deep reservoir and into a 1-acre by 4-foot-deep pond.

[2]Assumes a tanker truck carrying 1,000 gallons of spray mixture, dumping the entire load into a 16-acre by 8-foot-deep reservoir and into a 1-acre by 4-foot-deep pond.

[3]Diuron is not proposed for aerial application.

Cancer risk for the general public was calculated for a single exposure, and for 30 exposures over a lifetime. The approximate cancer risks to the public for the aerial routine-realistic scenario are shown in Table 8. Of the four chemicals, the greatest risks are for 2,4-D. The risk of cancer due to any of the routes of exposure in the typical aerial spraying scenario is less than 2 out of 10 million individuals exposed, even for 2,4-D. Cancer risks for the other chemicals are much less. The risk for glyphosate is never greater than 2 out of 1 billion individuals exposed. For asulam, and picloram, none of the routes of exposure in any scenario results in a cancer risk greater than about 2 out of 100 million individuals exposed.

Cancer risk to workers has been calculated for an expected case assuming 5 years of employment in herbicide application, and an average number of days of spraying per year. The average number of exposures per lifetime was estimated to range from 30 to 70. The risk has been calculated in the extreme case assuming 30 years of employment and a total of 288 to 480 exposures. It is very unlikely that a worker would apply herbicides on the number of days assumed in the worst-case. The highest risk for 2,4-D is about 1 out of 100,000 individuals exposed during backpack spraying in the expected case, and in the worst-case the greatest risk is about 1 out of 10,000. Workers using asulam in the worst-case have a lifetime cancer risk of less than 6 out of 100,000 individuals exposed in all worker categories. The risk of picloram or glyphosate use is even less for all worker categories. The risks in the expected case never exceed 3 out of 10 million individuals exposed.

The greatest cancer risks to the public among the four chemicals are for 2, 4-D (3 out of 10 million individuals exposed). Multiple incidents could be expected to result in cumulative risks. The greatest risks are for spills of herbicide concentrate directly onto clothing and skin. Workers are at the greatest risk for this type of accident. The calculated values assume that most of a person's skin has been contacted by the solution, and cleanup does not occur for several hours. This is certainly contrary to standard practice. A spill of 2,4-D concentrate onto a person gives a risk of about 3 out of 10,000, and a spill of spray mixture gives a lesser risk of about 1 out of 100,000, individuals exposed. The risk of cancer due to a spill of asulam is about 1 out of 100,000 for the concentrate and 1 out of 1 million for the spray mixture. A spill of picloram or glyphosate concentrate gives a risk of 2 out of 1 million or less. Cancer risks arising from even major spills into drinking water supplies are significantly less. A 100-gallon helicopter load of 2,4-D spray mixture dumped into a 1-acre pond would lead to a risk of cancer of not more than 1 out of 10 million individuals drinking a liter of the water. The corresponding risks for the other chemicals are much less. For a 1,000-gallon tank truck of spray

Table 8. Lifetime Cancer Risk—Exposed Public Realistic Aerial, 40 Acres by Helicopter

Routes of Exposure	Exposures per Lifetime	Risk[1] from Use of: 2,4-D	Asulam	Picloram	Glyphosate
For a Single Exposure					
Dermal, Spray Vegetation Contact	1	10^{-11}	10^{-12}	10^{-14}	10^{-13}
Hiker	1	10^{-13}	10^{-14}	10^{-16}	10^{-15}
Picker	1	10^{-9}	10^{-10}	10^{-12}	10^{-11}
Drinking Water	1	10^{-9}	10^{-10}	10^{-10}	10^{-11}
Eating Berries	1	10^{-9}	10^{-10}	10^{-11}	10^{-11}
Eating Vegets.	1	10^{-9}	10^{-10}	10^{-10}	10^{-11}
Eating Deer	1	10^{-10}	10^{-11}	10^{-12}	10^{-12}
Eating Fish	1	10^{-10}	10^{-10}	10^{-11}	10^{-12}
Combined Routes of Exposure					
Hiker	1	10^{-9}	10^{-10}	10^{-10}	10^{-11}
Berry Picker	1	10^{-9}	10^{-9}	10^{-10}	10^{-11}
Hunter	1	10^{-9}	10^{-10}	10^{-10}	10^{-11}
Fisherman	1	10^{-9}	10^{-10}	10^{-10}	10^{-11}
Resident	1	10^{-9}	10^{-10}	10^{-10}	10^{-11}
For 30 Exposures					
Dermal, Spray Vegetation Contact	30	10^{-10}	10^{-10}	10^{-12}	10^{-12}
Hiker	30	10^{-12}	10^{-12}	10^{-14}	10^{-14}
Picker	30	10^{-8}	10^{-8}	10^{-10}	10^{-9}
Drinking Water	30	10^{-8}	10^{-8}	10^{-9}	10^{10}
Eating Berries	30	10^{-8}	10^{-9}	10^{-9}	10^{-10}
Eating Vegets.	30	10^{-8}	10^{-8}	10^{-9}	10^{-10}
Eating Deer	30	10^{-9}	10^{-9}	10^{-10}	10^{-11}
Eating Fish	30	10^{-8}	10^{-9}	10^{-9}	10^{-10}
Combined Routes of Exposure					
Hiker	30	10^{-8}	10^{-8}	10^{-9}	10^{-10}
Berry Picker	30	10^{-7}	10^{-8}	10^{-9}	10^{-9}
Hunter	30	10^{-8}	10^{-8}	10^{-9}	10^{-10}
Fisherman	30	10^{-7}	10^{-8}	10^{-9}	10^{-10}
Resident	30	10^{-7}	10^{-8}	10^{-9}	10^{-9}

[1]All of these numbers shown exponentially are to be intrepreted as follows:

10^{-7} means 1 out of 10 million individuals exposed to a given herbicide via a given exposure scenario.

10^{-8} means 1 out of 100 million individuals,

10^{-9} means 1 out of 1 billion individuals, etc.

mixture of 2,4D spilled into a small pond, the risk would be about 1 out of 1 million.

Risk of Heritable Mutations

No human studies are available that associate any of the herbicides with heritable mutations. Furthermore, no risk assessments that quantify the probability of mutations are available in the literature or from EPA. Laboratory studies constitute the best available information on mutagenic potential. Results of the mutagenicity assays conducted on the 11 herbicides are summarized in Table 4.

Asulam and glyphosate tested negative for mutagenicity in all assays conducted, and thus can be considered to pose no mutagenic risk.

Fosamine, hexazinone, and triclopyr were nonmutagenic in the great majority of assays conducted and were nononcogenic in all of the carcinogenicity tests performed; therefore, it can be assumed that their mutagenic risk is slight to negligible. Dicamba was nonmutagenic in most of the assays performed and no oncogenicity was found in several long-term studies. However, EPA has classified the chronic studies as "inadequate to evaluate the oncogenic potential of dicamba."

No validated mutagenicity studies have been conducted with either dalapon, or diuron. The worst-case assumption is that these chemicals are mutagenic. The probability that dalapon or diuron would cause heritable mutations is low because they have not been shown to cause cancer in any long-term studies.

The negative oncogenic studies for diuron were classified by EPA as inadequate to determine carcinogenic potential to mammalian organisms. The lack of positive results in any mutagenic or oncogenic tests with diuron suggests that diuron would present only minute risk to humans as a mutagen.

Atrazine tested positive for mutagenicity in 15 of 33 assays. The worst-case assumption is that atrazine is mutagenic. However, many of the positive results were achieved through tests that may not be relevant to evaluating mutagenic risk in humans. Some positive results in rodents were also achieved, but these responses were only observed at levels greater than 1,500 mg/kg body weight. These are exceptionally high dose levels and suggest that the degree of germ cell hazard from low levels of atrazine would be minimal at worst.

For picloram and 2,4-D, there have been only a few studies performed and these have indicated both positive and negative mutagenic potential. EPA has requested more mutagenicity test information for both of these com- pounds. A number of comprehensive reviews of the 2,4-D mutagenic data have indicated that it does not pose significant risk of human gene mutations. The herbicide 2,4-D has been shown to be nononcogenic in the two carcinogenicity studies that have been conducted. Based on a worst-case estimate, the risk of heritable mutations from these chemicals would be no greater than the cancer risk.

Synergistic Effects

Synergistic effects of herbicides are those that occur because of simultaneous exposure to more than one herbicide and that cannot be predicted based on the effects of the individual chemicals. It is possible but unlikely that synergistic effects could occur as a result of exposure to two or more of the herbicides considered in this analysis.

It is highly unlikely that synergistic adverse effects could result from exposure to more than one herbicide applied in separate projects. The only herbicide mixtures used are combinations that have been registered for use by the Environmental Protection Agency. EPA has considered the possibility of synergistic effects in these cases and found that the risk is not significant.

Cumulative Effects

No one individual member of the public is likely to receive repeated exposures to any of the herbicides because of the remoteness of most treatment units, the widely spaced timing of repeated treatments, and the use of a variety of herbicides for different purposes. In addition, the precautions taken by the Forest Service and BLM during treatment operations make any dose at all to the public highly unlikely. This risk assessment used the lowest NOELs found in chronic animal laboratory studies for comparison with estimated human doses. The risk analysis results show that, except for triclopyr, margins-of-safety for the public from realistic treatment scenarios are greater than 200. Thus, members of the public could receive doses of herbicides other than triclopyr repeatedly over the years, even though the chance of receiving multiple doses is negligible, and still not suffer toxic effects. Some individuals who are particularly sensitive to triclopyr could experience ill effects but, again, this should occur only in the unusual circumstance of repeated doses. Compared to the levels of exposure to the pesticides used in agriculture and related commercial operations in Washington and Oregon, the exposures to humans from Forest Service and BLM operations from year to year would be insignificant. Therefore, cumulative effects on the public should be negligible.

Cumulative effects on workers have been considered throughout this analysis. The risk of workers experiencing toxic effects, including cancer, assumes that they are continually exposed to these herbicides. Backpack applicators are at greatest risk from cumulative effects.

Appendix L
Supplement to the Environmental Impact Statements of Management of Competing Vegetation

Human Health Risk Assessment for the Use of Herbicides in the Vegetation Management Programs of the U.S. Forest Service in Washington and Oregon and the Bureau of Land Management in Western Oregon

Prepared for the USDA Forest Service and the USDI Bureau of Land Management

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Section 1 Introduction

Purpose

The purpose of this analysis is to assess the risk to human health of using 16 different herbicides for vegetation management on Forest Service lands located in Washington and Oregon and on Bureau of Land Management (BLM) lands in western Oregon. This risk assessment is a supplement to the Forest Service Environmental Impact Statement (EIS) entitled **Methods of Managing Competing Vegetation: A Programmatic Environmental Impact Statement** (1981) and the BLM EIS entitled **Western Oregon Program: Management of Competing Vegetation** (1983). Both EIS's analyzed the environmental impacts of using various alternatives for managing competing vegetation in the Pacific Northwest.

Overview of the Risk Assessment

This risk assessment examines the potential health effects on all persons who might be exposed to any of the 16 herbicides as a result of activities related to the vegetation management programs. People potentially at risk are separated into two categories. The first group—workers—includes applicators, supervisors, and other personnel directly involved in the application of herbicides. The second group—the public—includes forest visitors or nearby residents who could be exposed through the drift of herbicide spray droplets, through contact with sprayed vegetation, or by eating vegetation (such as berries), game, or fish containing herbicide residues or drinking water that contains such residues.

The risk assessment includes analyses of a range of possible exposures—from realistic to worst case—resulting from herbicide application. Typical application scenarios (routine-realistic) are used to estimate the doses to workers and to members of the public who may be nearby that may reasonably be expected to occur during routine operations. Extreme application scenarios (routine-worst case) are used to give very high dose estimates that are not likely to be exceeded except in the case of an accident. Accident scenarios (accidental-worst case) are used to estimate doses to workers and the public that may result from direct exposure to the herbicide spray mix or concentrate or from drinking water into which a truckload of herbicide mixture or a drum of herbicide concentrate has been spilled.

Health risks are evaluated by comparing dose estimates for workers and the public with appropriate hazard levels found in laboratory test animals. The analysis estimates the risk of acute health effects (arising from single exposures to each of the herbicides) and the risk of chronic health effects arising from a single exposure or from repeated exposures to a herbicide over a period of time.

The risk of cancer caused by herbicides that are known or suspected carcinogens is estimated by comparing lifetime doses computed for workers and the public with worst case cancer potency estimates derived from studies on laboratory animals. Individual cancer risk is presented in terms of the likelihood that an individual could get cancer in his or her lifetime from a specified level of exposure to a given herbicide.

Structure of the Risk Assessment

An assessment of the risk of human health effects from the use of herbicides in vegetation management programs requires determining what human exposures could occur as a result of herbicide applications and estimating the probability and extent of adverse health effects as a result of those exposures. This risk assessment employs the three principal analytical elements described by the National Research Council (1983) as necessary to characterize the potential adverse health effects of human exposures to existing or introduced hazards in the environment: hazard analysis, exposure analysis, and risk analysis.

1. Hazard Analysis requires gathering information that is used to determine the toxic properties of each herbicide. Human hazard levels are derived primarily from the results of laboratory experiments on animal models, such as rats, mice, and rabbits, supplemented where appropriate with information on human poisoning incidents, field studies of other organisms, and data on chemical structure.

2. Exposure Analysis involves estimating single and multiple exposures to persons potentially exposed to the herbicides, determining the doses likely to result from those estimated exposures, and determining the number and characteristics of persons in the exposed populations.

3. Risk Analysis requires comparing the hazard information with the dose estimates and the probability that they could occur to predict the health effects to individuals under the given conditions of exposure.

The relationships among these three components

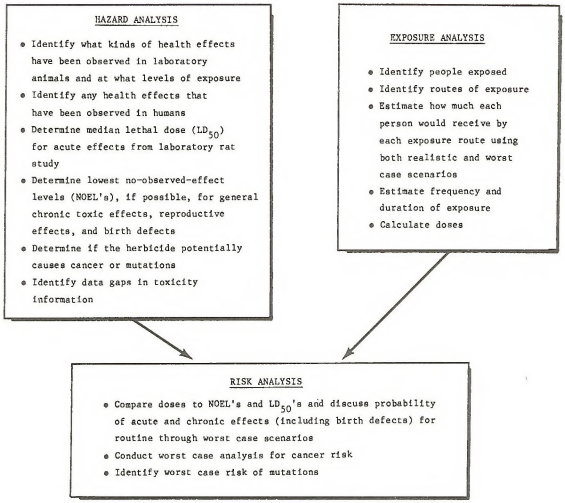

HAZARD ANALYSIS
• Identify what kinds of health effects have been observed in laboratory animals and at what levels of exposure
• Identify any health effects that have been observed in humans
• Determine median lethal dose (LD_{50}) for acute effects from laboratory rat study
• Determine lowest no-observed-effect levels (NOEL's), if possible, for general chronic toxic effects, reproductive effects, and birth defects
• Determine if the herbicide potentially causes cancer or mutations
• Identify data gaps in toxicity information
EXPOSURE ANALYSIS
• Identify people exposed
• Identify routes of exposure
• Estimate how much each person would receive by each exposure route using both realistic and worst case scenarios
• Estimate frequency and duration of exposure
• Calculate doses
RISK ANALYSIS
• Compare doses to NOEL's and LD_{50}'s and discuss probability of acute and chronic effects (including birth defects) for routine through worst case scenarios
• Conduct worst case analysis for cancer risk
• Identify worst case risk of mutations

Figure 1-1 Components of the Risk Assessment Process

are illustrated in Figure 1-1. This risk assessment identifies uncertainties, such as areas where scientific studies are unavailable, and presents the results of all worst case analyses. The discussion that follows describes briefly how each component in the structure was addressed in this risk assessment.

Hazard Analysis

The 16 herbicides being considered by the Forest Service and BLM in their vegetation management programs are amitrole, asulam, atrazine, bromacil, 2,4-D, 2,4-DP (dichlorprop), dalapon, dicamba, diuron, fosamine, glyphosate, hexazinone, picloram, simazine, tebuthiuron, and triclopyr. The hazard involved in the use of each of the herbicides was determined in a thorough review of available toxicological studies. Where no studies have been conducted in a particular area, for example, mutagenicity, these areas are identified and a worst case analysis is conducted in Section 5. Scientific uncertainty regarding the results of these studies, for example, concerning the results of the cancer studies on glyphosate and 2,4-D, is also discussed. The hazard analysis is discussed in Section 3.

The toxicological data base for each herbicide was reviewed for acute and chronic effects on test animals. Toxicity information is summarized for 12 of the 16 herbicides in the background statements of Forest Service Agricultural Handbook No. 633 (USDA, 1984). Tebuthiuron toxicity is reviewed in a background statement prepared for the Forest Service as a supplement to Handbook No. 633. Toxicity information is summarized for the herbicides asulam, diuron, and bromacil in background statements written in conjunction with this risk

assessment. These documents are incorporated by reference into this Supplement in accordance with 40 CFR 1502.21 and are available for review at all Forest Service and BLM District Offices in Oregon and Washington as well as at the address shown on the cover page.

Exposure Analysis

To estimate the potential human exposures to the 16 herbicides, the various aspects of the vegetation management programs of the Forest Service and Bureau of Land Management in Washington and Oregon that employ herbicides to control vegetation were examined. The major aspects of the vegetation management programs that determine the potential levels of herbicide exposure were identified, including human activities associated with or in proximity to treatment areas, application methods, application rate, size and configuration of spray areas, project design features, and mitigation measures.

Herbicide Spraying Operations

The 16 herbicides examined in this risk assessment are applied aerially, using fixed-wing or helicopter aircraft, or on the ground, using trucks or tractors, backpack sprayers, or handheld application devices. Table 1-1 shows the types of operations where the herbicides are used and the approximate yearly acres affected in Region 6 for the Forest Service and in western Oregon for BLM. The cumulative analysis makes the worst case assumption that 100,000 acres are treated each year as a result of the combined programs. The size of the program and the mix of activities may vary in any given year as described in each parent EIS.

Table 1-1
Herbicide Spraying Operations for Forest Service and BLM Lands

Treatment Operations	Forest Service Acres	BLM Acres
Silviculture: Site Preparation and Conifer Release	27,000 - 35,000	38,800 - 44,100
Right-of-Way Management	3,000 - 6,000	1,900
Noxious Weed Control	1,400 - 1,600	300[a]
Range Improvement	2,000 - 5,000	----[b]
Facilities and Recreation Site Maintenance	100 - 150	----[b]

[a]BLM has prepared a separate EIS on noxious weed control. U.S. Department of the Interior, BLM. Northwest Area Noxious Weed Control Program, Final EIS December 1985.

[b]Included in BLM's noxious weed control program.

These annual programs would involve a limited number of large projects and many small projects ranging from one to many separate treatment units. Individual silviculture treatment units within a project typically range from 15 to 60 acres. A number of individual sites are normally treated at one time, with 120 to 150 acres normally treated per day. Occasionally there are treatment areas much smaller (less than 1 acre) or much larger (up to 200 acres), especially on wildlife rehabilitation projects. Treatment units for range management projects are generally larger, with 200 to 400 acres normally treated each day.

More than 100 projects, with treatment units ranging in size from less than 1 acre (for facility maintenance) to 400 acres for range management, occur annually on BLM lands in western Oregon and Forest Service lands within Region 6. The area treated with various herbicides in 1982 was less than 1 percent of the possible 21,746,000 acres of National Forest land in Region 6. Slightly more than 1 percent of the 2,383,000 acres of land administered by BLM in western Oregon was treated with herbicides in 1982. Further details about these operations are given in the parent EIS's and in Section 2.

Affected Populations

In calculating the potential doses to persons at risk from herbicide applications, two populations were considered: workers and the general public. The workers included the personnel directly involved in the spray operations: the mixers and loaders, the truck-sprayer applicators and drivers, the backpack sprayers, the hand applicators, the pilots, the observers, and the supervisors. The public included forest visitors and nearby residents who may be directly exposed to herbicide as a result of drift, by contact with vegetation that has received herbicide drift, or by being accidentally sprayed. The public may be indirectly exposed by eating food items or drinking water containing herbicide residues.

Routine Exposure Scenarios

This risk assessment examines the health effects of exposure to an individual herbicide treatment as well as the cumulative effects of exposure over a number of years. To represent the range of doses under normal operating procedures, eight application scenarios were used. Under the routine-realistic scenario, four application methods, employing normal herbicide application rates and typical treatment unit sizes, were used to calculate realistic doses to workers. Doses to members of the public who may be in the area or who may live nearby

were calculated for aerial, truck, and backpack scenarios. No public exposures were expected from hand-application treatments because drift is negligible from these methods.

Four additional scenarios, using the same application methods as routine-realistic but employing the highest application rates likely to be used and the largest treatment unit sizes under conditions conducive to offsite herbicide drift, were used to estimate routine-worst case doses to workers and the public. These dose estimates purposely overestimate doses expected from routine applications.

Cumulative doses were estimated by using information on average and maximum treatment days per year and on average and maximum number of years exposed for workers and for the public.

Accident Exposure Scenarios

Because all human activities involve the possibility of error, the use of herbicides in vegetation management involves the possibility that humans may inadvertently receive unusually high exposures to the herbicides because of accidents.

To examine what potential health effects could occur in an accidental situation, a number of accidental-worst case scenarios are analyzed. Exposures analyzed include direct aerial application of herbicide on a person, spills of concentrate or herbicide mix on workers in mixing and loading, and spills of herbicide into drinking water supplies. One accidental scenario assumes that a person enters a treated area (ignoring warning signs) before any herbicide has dried or degraded.

The probabilities of these accidental scenarios range from unlikely to extremely unlikely. Wherever possible, historical records of accidents were used in determining the probabilities of accident occurrence.

Dose Estimation

Estimates of routine doses to workers were derived from field studies on the five herbicides (2,4-D, 2-4-DP, dicamba, amitrole, and picloram) for which that information is available (see Table 4-3). Where no studies existed on a particular herbicide, doses were extrapolated from a 2,4-D worker exposure study that used the same application method.

Worker exposures to each herbicide were based on the worker's task, for example, backpack sprayer, pilot, mixer-loader, and so forth, rather than the type of vegetation management project because the same equipment and procedures are often used in these operations. The exposures between operation types are weighted by application rate and number of hours worked per day. Where the exposure of a worker in a particular task, such as mixer-loader, is significantly different from one project type to another, that exposure is determined separately for each representative operation.

Exposures and doses to members of the general public were derived by using data on herbicide drift from field studies and by applying various assumptions about dermal penetration, amount of skin exposed, and diet. Details of the exposure analysis are given in Section 4.

Risk Analysis

Human health risks of the vegetation management program were evaluated by comparing the doses of workers and the general public calculated for routine operational and accidental exposure scenarios to the laboratory-determined toxicity levels described in the hazard analysis.

Risk of acute and chronic threshold effects is evaluated by comparing estimated doses to toxicity reference levels derived from LD 50's and NOEL's (no-observed-effect levels) in laboratory animal studies, and a margin of safety (MOS) is derived. Risk increases as the estimated dose approaches the laboratory toxicity level.

Nonthreshold risk, that is, the potential for these herbicides to cause cancer and mutations, was evaluated differently. The analysis showed that currently there is scientific uncertainty regarding the potential of five of the herbicides–amitrole, picloram, 2,4-D, 2,4-DP, and glyphosate–to cause cancer in humans. Therefore, this risk analysis uses the worst case assumption that these five herbicides would cause cancer in exposed persons. The risk of cancer at a given level of exposure, based on the estimated average daily exposure over a 70-year lifetime, was derived for the herbicide in question from laboratory animal data on tumor incidence at increasing dose levels. These data were corrected for species differences, body size difference, dose frequency, and duration of exposure; and the risk of cancer was calculated for various categories of people that may be exposed to the herbicides.

The risks of heritable mutations are discussed based on available test data on bacteria, yeasts, plants, mammalian cells in culture, and whole animals. Where no test data are available, a worst case assumption is made that these herbicides are mutagenic and that risk is compared to the herbicide's cancer risk.

Cumulative risk for individuals is discussed in terms of lifetime exposures to a given herbicide for

workers and for members of the public. Risk of synergistic effects is discussed in terms of the available evidence of enhanced toxicity in mixtures of two or more herbicides. Risk to sensitive individuals is discussed qualitatively in terms of the likelihood of a sensitive individual being exposed.

Worst Case Analysis Requirements

As indicated earlier, this document is a supplement to the Forest Service and BLM Environmental Impact Statements named on page 1-1 and has been prepared pursuant to the requirements of the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations for implementing NEPA. The CEQ regulations (40 CFR 1502.22) state:

> When an agency is evaluating significant adverse effects on the human environment in an environmental impact statement and there are gaps in relevant information or scientific uncertainty, the agency shall always make clear that such information is lacking or that uncertainty exists.
>
> (a) If the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.
>
> (b) If (1) the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are exorbitant or (2) the information relevant to adverse impacts is important to the decision and the means to obtain it are not known (e.g., the means of obtaining it are beyond the state of the art) the agency shall weigh the need for the action against the risk and severity of possible adverse impacts were the action to proceed in the face of uncertainty. If the agency proceeds, it shall include a worst case analysis and an indication of the probability or improbability of its occurrence.

This risk assessment identifies a number of uncertainties or data gaps, including the following:

1. Field studies on exposure to workers for all of the herbicides except 2,4-D, 2,4-DP, dicamba, amitrole, and picloram.

2. Information on exposure of the public to the 16 herbicides.

3. Field data on residue levels in plants and animals most likely to be found in and around treatment areas for some of the herbicides.

4. Mutagenicity studies for bromacil, dalapon, and diuron.

5. The potential for amitrole, asulam, bromacil, 2,4-D, 2,4-DP, picloram, and glyphosate to cause cancer.

6. Toxicity information on the synergistic effects from exposure to more than one herbicide.

These areas of uncertainty are important in deciding what is the best alternative for action; however, the cost of obtaining this information is an important consideration. From discussions with the Environmental Protection Agency, the Department of Agriculture, the Department of the Interior, and the chemical manufacturers, it is estimated that the costs per chemical of conducting some of the standard laboratory toxicity tests would be $1.5 to $2.0 million for a chronic toxicity study with rats and dogs; $1.5 to $2.5 million for an oncogenicity test with rats and mice; and $50,000 to $100,000 for each mutagenicity and chromosomal study.

The estimated costs to fill the specific data gaps listed above are:

1. Worker exposure studies would cost approximately $200,000 per chemical.

2. No acceptable protocol is available for measuring all of the various routes of exposure of the public, but these studies would be more expensive than the worker exposure studies.

3. The cost of measuring residues in plants and animals would be between $50,000 and $100,000 per chemical per plant or animal.

4. The mutagenicity and chromosomal studies for bromacil, dalapon, and diuron would cost approximately $450,000.

5. The five oncogenicity studies for amitrole, asulam, bromacil, 2,4-D, 2,4-DP, picloram, and glyphosate would cost approximately $11.2 million.

6. Synergistic studies would be extremely expensive because of the great number of tests that would be necessary; there are 120 combinations of the 16 herbicides if studied two at a time.

The overall cost of conducting the studies to fill the data gaps is considered exorbitant with respect to the limited funds available to the Forest Service and BLM. In addition, the time needed to perform

and evaluate most of these tests is more than 2 years and would seriously delay the implementation of the vegetation management programs. Many of the outstanding toxicological studies have already been requested by EPA, and the results of these studies will be considered when they become available. In addition, both agencies have ongoing research and monitoring programs to examine the various aspects of herbicide treatment, and these results will be considered as they become available.

Because the cost of filling the data gaps is considered exorbitant, a worst case analysis was conducted for those areas where information is not available or when there is uncertainty. The probability of a worst case occurring was also estimated. The worst case analyses for the first three uncertainties listed on page 1-8 involved estimating the upper limit of herbicide exposure from routine application procedures and from accidents. The worst case scenarios involving routine herbicide application operations consist of those combinations of parameters, such as treatment unit size, duration of exposure, application rate, application equipment, and meteorological conditions, that give the highest reasonable exposure value. Worst case accidents include direct spills of concentrate on workers' skin, the direct spraying of an individual, and public exposure through drinking water contaminated by a spill.

The worst case analysis for the mutagenicity of chemicals for which there is no data or where there is some positive testing for mutagenicity assumed that all these herbicides could cause mutations. The probability of mutagenic activity was based on available cancer data. The worst case analysis for herbicides that had either positive cancer studies or for which there is scientific uncertainty assumed that these chemicals could cause cancer. The most conservative cancer potency value for a chemical was computed by using the highest rates of tumor formation found in the available animal studies. The most conservative model for predicting cancer rates was also used. The worst case analysis for synergistic effects assumed that these effects could occur. The probability of these effects occurring was considered low.

Although there are data gaps or areas of uncertainty for some of the herbicides in this risk assessment, there is a large body of existing data that is useful in predicting the behavior and toxicity of these herbicides. These studies include the following:

1. Worker exposure studies with 2,4-D, 2,4-DP, dicamba, amitrole, and picloram.

2. Studies on drift of 2,4-D and glyphosate.

3. Residue information for a number of the herbicides in plant and animal tissues.

4. Cancer studies for those herbicides without mutagenicity studies.

5. Oncogenicity studies with negative results for those herbicides where oncogenicity is uncertain, including two for 2,4-D, two for 2,4-DP, two for asulam, one for bromacil, one for glyphosate, and three for picloram.

Organization of This Supplement

Section 1 presents the purpose, describes the structure, and outlines the methodology of the risk assessment. Section 2 outlines the vegetation management programs that use herbicides and the mitigation measures practiced in each. Section 3, the hazard analysis, summarizes and discusses the toxic properties of each herbicide, including the cancer potency of the known or suspected carcinogenic herbicides. Section 4, the exposure analysis, describes the methods used to estimate levels of exposure and resultant doses to workers and the public and presents summary tables and discussions of estimated acute and long-term doses. Section 5, the risk analysis, presents the comparison of the results of the exposure analysis with the toxic effect levels set forth in Section 3. Section 5 also discusses cancer risk, given estimated lifetime doses to workers and the public. Attachment A presents the details of the mutagenicity and cancer testing done on many of the herbicides. Attachment B provides the complete dose estimates for workers and the public derived from the methods described in the exposure analysis. Attachment C presents the complete margin-of-safety tables used in the risk analysis.

Section 2 Vegetation Management Programs

This section describes the vegetation management programs that the Forest Service and BLM conduct in Washington and Oregon involving the use of herbicides. The first subsection briefly describes the different types of vegetation management programs that use herbicides. The second subsection identifies the application methods and the principal herbicides used in those programs. The final subsection discusses mitigation measures used to minimize the possible adverse effects of the herbicides on human health and the environment. Complete descriptions of the Forest Service and BLM vegetation management programs are found in the environmental impact statements that this document supplements.

Program Descriptions

The Forest Service and BLM conduct vegetation management programs on Federal lands in Washington and Oregon to sustain and improve the ability of those lands to produce timber, livestock forage, and wildlife; to ensure public safety on roads, other rights-of-way, and recreation sites; and to protect facilities and capital improvements. Herbicides are proposed for use in these programs as described in the Forest Service and BLM environmental impact statements cited in Section 1.

Silviculture operations, designed to ensure the establishment and healthy growth of timber crop species, are the largest proposed program for herbicide treatment by both the Forest Service and BLM (see Table 2-1). These operations include site preparation, plantation maintenance, conifer release, precommercial thinning, and noncommercial tree removal. Site preparation treatments are used to prepare newly harvested or inadequately stocked areas for planting a new crop of trees. Use of herbicides in site preparation reduces vegetation that would compete with the conifers. In the brown and burn method of site preparation, herbicides are used to dry the vegetation, which several months later is burned. Herbicides are used in plantations some time after planting to promote the survival and establishment of conifers (maintenance) or to promote the dominance and growth of already established conifers (release). Precommercial thinning reduces competition among conifers, thereby improving the growth rate of the crop trees. Noncommercial tree removal is used to eliminate dwarf mistletoe-infected host trees. These latter two silvicultural practices primarily use manual methods, although the use of herbicides constitutes about 2 to 5 percent of the operations. On the basis of total

Table 2-1
Typical Annual Acres Treated by Vegetation Management Program

Application Method	Silviculture	Noxious Weeds	Rights-of-Way	Facility Maintenance	Range Management	Total
			Forest Service, Region 6			
Aerial Treatments	16,500	100	300	0	1,750	18,650
Ground Treatments	14,500	1,400	4,200	125	1,750	21,975
All Treatments	31,000	1,500	4,500	125	3,500	40,625
			Bureau of Land Management, Western Oregon			
Aerial Treatments	34,500	0	400	0	—	34,900
Ground Treatments	7,000	275	1,500	25	—	8,800
All Treatments	41,500	275	1,900	25	—	43,700

acreage managed, the Forest Service has historically used herbicides in about 12 percent of its site preparation work, BLM in about 30 percent. The Forest Service has used herbicides in approximately 80 percent of its maintenance and release projects, BLM in more than 90 percent.

Right-of-way management operations include roadside maintenance and maintenance of power transmission lines, waterways, and railroad corridors. In roadside maintenance, vegetation is removed from ditches and the shoulders of roads to prevent brush encroachment into driving lanes, to maintain visibility on curves for the safety of vehicle operators, to permit drainage structures to function as intended, and to facilitate maintenance operations. Herbicides have been used in 16 percent of the Forest Service's roadside maintenance in Region 6. In western Oregon, 30 percent of BLM's roadside maintenance has historically used herbicides.

Noxious weed control programs control noxious and poisonous plants harmful to humans or domestic livestock. Plants most often treated are poison oak, tansy-ragwort, St. Johnswort, skeleton weed, and thistle. BLM's noxious weed control program is analyzed in a separate EIS, "Northwest Area Noxious Weed Control Program" (BLM, 1985).

The Forest Service and BLM have used herbicides extensively in their noxious weed program. The Forest Service has historically used herbicides on almost all acres of noxious weed treated.

Range improvement operations provide forage for domestic livestock grazing by removing undesirable competing plant species and preparing seedbeds for desirable plants. The Forest Service uses herbicides on about 12 percent of its range improvement acreage in Region 6. BLM's range improvement program will be evaluated in a separate EIS.

Facilities and recreation site maintenance operations provide for the safe and efficient use of Forest Service and BLM facilities and recreation sites and for permittee/grantee use of such public amenities as ski runs, waterways, and utility terminals. BLM includes its facility maintenance in its roadside maintenance and weed control program. The Forest Service uses herbicides on less than 11 percent of the total acreage maintained by its facility and recreation site maintenance operations.

Application Methods and Herbicide Usage

Herbicides are applied either from the air or on the ground. Aerial methods employ boom-mounted nozzles carried by helicopters or fixed-wing aircraft. Ground application methods include vehicle-mounted, backpack, and hand application techniques. Vehicle-mounted application systems use fixed-boom or hand-held spray nozzles mounted on trucks or tractors. Backpack systems use either a pressurized sprayer or a powered mist blower to apply herbicides as a broadcast spray directly to one or a group of individual plants.

The principal hand application techniques are injection and stump treatment. Injection involves the application of herbicide in hand-held containers or injectors through slits cut into the stems of target plants. Individual stem treatment by the injection method also is used for crop tree thinning or removal of weed trees. Hack-and-squirt and injection bar equipment are most often used in injection treatments. Stump treatment entails directly applying liquid herbicide to the cut stump of the target plant. The herbicide can be applied by dabbing or painting the stump, or using a squeeze bottle on a freshly cut surface to inhibit sprouting. Herbicides may also be applied by hand in solid form as granules spread on the ground surface.

Although all of the application methods have been used in every type of management operation (except aerial methods on facility or recreation sites), only one or two methods are routinely used. Table 2-2 lists the application methods used in each type of management program with an indication of which methods are commonly used and which are only rarely used. Table 2-1 lists Forest Service and BLM acres treated in each management program by aerial and ground methods in a typical year. Actual historical data were used in determining these typical acreages.

The principal herbicides used by both agencies in terms of total acres treated in all programs are 2,4-D, glyphosate, and triclopyr. Figures 2-1 and 2-2 illustrate the historical proportion of total treated acreage for each of the 16 herbicides used by the Forest Service and BLM.

Aerial Methods

The Forest Service treats more than half of its herbicide-treated silviculture and range management sites by air, as indicated in Table 2-1. BLM treats more than 80 percent of its silviculture sites by air. In general, helicopters are used on silviculture projects because the many treatment units are far apart, small and irregularly shaped, and in steep terrain. Herbicides are normally released 30 to 90 feet above vegetation as medium-sized droplets in an 80- to 90-foot swath. On an average day, several treatment units totaling 150 acres can be sprayed.

Table 2-2
Herbicide Application Methods Used in Forest Service and Bureau of Land Management Vegetation Management Programs

Application Method	Project Type: Silviculture: Site Preparation	Silviculture: Conifer Release	Range Improvement	Noxious Weeds	Right-of-Way Maintenance	Facilities and Recreation Site Maintenance
Aerial						
Fixed Wing	R	R	O	O	R	
Helicopter	C	C	O	O	C	
Mechanical						
(Truck-mounted or towed sprayer)	R	R	O	O	C	O
Backpack	C	C	O	O	O	C
Hand	O	O	R	R	O	O

Legend
C = Commonly Used
O = Occasionally Used
R = Rarely Used
Blank = never used

Fixed-wing aircraft commonly are used on range management and noxious weed projects in which large contiguous areas are treated. Herbicides are generally released at the same height and swath width as in helicopter treatments. For a large treatment unit, 400 acres can be treated each day.

Batch trucks are an integral part of any aerial operation. They serve as mixing tanks for preparing the correct proportions of herbicide and carrier, and they move with the operation when different landing areas are required.

The number of workers involved in a typical aerial spray project varies according to the type of activity. A small operation may require only 6 individuals, while a complex spray operation may need as many as 20 to 25 workers. The aerial operations crew for range management, noxious weed control, and right-of-way maintenance normally consists of five to eight individuals. Typical personnel on a large project include a pilot, a mixer-loader, a contracting officer's representative (COR), an observer-inspector, a one- to six-member card crew, one or two law enforcement officers, one or two water monitors, and one or two laborers. Optional personnel include an air operations officer, a radio technician, a weather monitor, and a recorder.

The following discussions are based on historical data on actual acres treated from the Forest Service Region 6 and BLM in western Oregon.

Forest Service Aerial Projects

In terms of total annual Forest Service herbicide use, the aerial application of herbicides in silviculture and range management programs normally constitutes about one-third of the herbicide applied.

2,4-D, glyphosate, and triclopyr have historically been the principal herbicides used for the Forest Service's aerial silviculture operations. The main herbicides used in aerial range management have been atrazine, dalapon, and 2,4-D. Picloram and 2,4-D have been the principal herbicides used on the small number of acres treated aerially for noxious weed control and right-of-way maintenance by the Forest Service. In some years, there has been no aerial spraying of rights-of-way.

Aerial silviculture treatment units vary in size from 2 acres to 60 acres. Normally, aerial treatment units are no more than 40 acres. Based on a 150-acre-per-day application schedule, there were roughly 100 total treatment days. Region 6 Forest Service personnel estimate that aerial silviculture

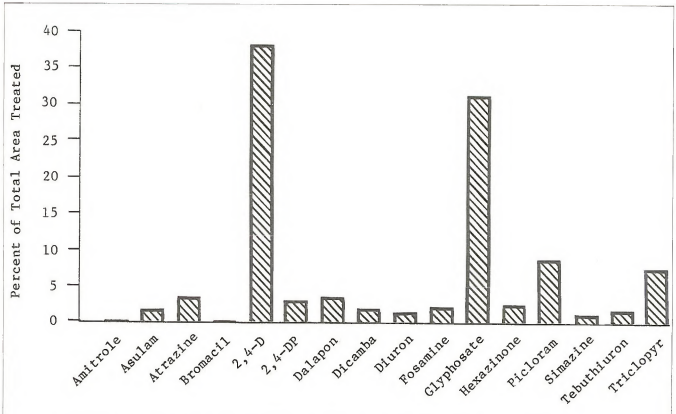


Figure 2-1 Historical Herbicide Use in Region 6 National Forests

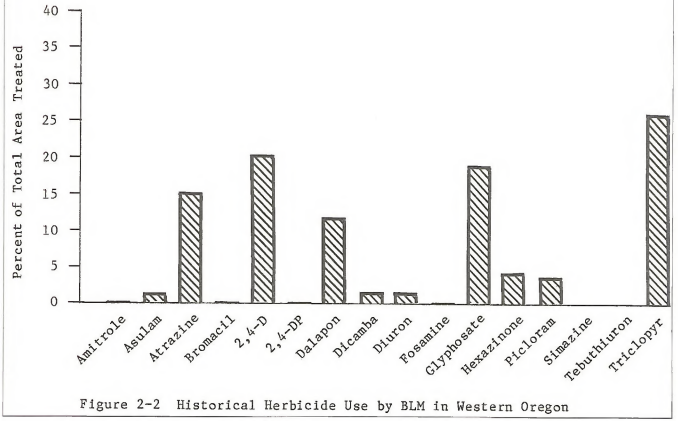


Figure 2-2 Historical Herbicide Use by BLM in Western Oregon

programs require 200 to 250 total workers and 2,500 to 3,500 total worker days of labor each year. Range improvement operations may include two or three large aerial projects per year, with treatment units ranging up to 400 acres. The annual work force for range projects was estimated at 25 to 30 workers and 300 to 350 total worker days.

BLM Aerial Projects

Historically, more than 80 percent of the total acres treated by BLM was for aerial silviculture projects. Five principal herbicides have historically been used by BLM aerial silviculture programs: 2,4-D, glyphosate, triclopyr, atrazine, and dalapon. Aerial treatments for right-of-way maintenance using primarily 2,4-D and triclopyr normally accounted for less than 1 percent of the total treated acreage.

Silviculture projects make up the bulk of BLM's aerial operations. BLM generally applies herbicides on about 150 acres/day in aerial treatments. An average of six individuals are normally involved in each of BLM's aerial spray operations.

Ground-Based Methods

Forest Service Ground-Based Treatment Projects

Silviculture and Range Management Projects. Ground treatment in silviculture and range management programs accounted for nearly half of the total acreage treated with herbicides by the Forest Service in 1982 and 1983. Glyphosate, 2,4-D, picloram, and triclopyr were the major herbicides used during ground-based silvicultural treatment in those years. Rangeland was treated predominantly with atrazine, dalapon, and 2,4-D.

Backpack treatment is the predominant ground-based method used for silviculture, although stump treatment and injection also are used. Herbicides may also be applied in granular form. Backpack treatment is also the predominant ground-based method used in range management.

Pressurized backpack treatment operations typically involve a supervisor (who may also function as a mixer-loader), an inspector, a monitor, and 2 to 12 crew members. Backpack sprayers can typically treat one-half of an acre per hour in silviculture operations. Four laborers and one inspector generally make up the work force for stump treatment or injection.

Major ground-based silviculture programs of the Forest Service in 1982 involved treatment of 300 or more acres in eight of the National Forests within Region 6. A total of 100 to 150 workers and 3,800 to 4,300 total worker days was estimated as a yearly labor allotment.

Right-of-Way Projects. In Region 6, areas treated with herbicides during right-of-way and road maintenance projects historically account for about one-fifth of the total acres treated. Treatments are normally done by permittees of the Forest Service (State highway departments, county road crews, utility companies, and the like). Fosamine, 2,4-D, 2,4-DP, picloram, tebuthiuron, and diuron were the most heavily used herbicides in this program.

Right-of-way maintenance projects frequently use vehicle-mounted application techniques. A truck with a mixing/holding tank uses a front-mounted spray boom or a hand-held pressurized nozzle to treat roadside vegetation on varying slopes. Use of this equipment for off-road right-of-way projects is limited to gentle slopes (less than 20 percent) and open terrain. Contractors spray an average of 30 to 50 acres per day with vehicle-mounted applicators. A driver/mixer-loader and applicator constitute the typical crew for truck spraying. A total of 3,000 to 3,500 worker days and 100 to 125 workers was estimated as a yearly quota for right-of-way maintenance projects.

Noxious Weed Control Projects. Forest Service use of ground-applied herbicides for noxious weed control normally accounted for less than 5 percent of the total acreage treated in both 1982 and 1983. Nearly half of the noxious weeds affected were on rangelands. 2,4-D, picloram, and dicamba are the principal herbicides used for noxious weed control. Backpacks, spray bottles, and trucks or tractors with spray booms or tractor-mounted attachments are used in ground-based noxious weed programs. Backpack sprayers can typically treat only 1 acre every 3 to 4 hours in noxious weed control programs because target plants are normally found as scattered individuals or in small groups. About one-fourth of the total acres treated in noxious weed control projects was hand-treated with herbicides in granular form. Noxious weed control programs, using both aerial and ground methods, account for 1,500 to 2,200 total worker days and 140 to 150 workers per year.

Facility Maintenance Projects. Facility maintenance by the Forest Service resulted in treatment of about 1 percent of the total acreage controlled by herbicides in 1982 and 1983. Amitrole, glyphosate, 2,4-D, and 2,4-DP were the major herbicides used in 1982, while glyphosate and 2,4-D were the predominant herbicides applied in 1983. All methods of ground application may be used and would typically involve only one or two applicators and one supervisor who would check on the work

after the task was completed. Many small short-term projects throughout the Region have resulted in a total treatment of 100 to 125 acres annually.

BLM Ground Application Projects

Ground-based methods of herbicide application are not used as extensively by BLM as they are by the Forest Service. Manual methods are often used in silviculture projects, and controlled burning is commonly used for site preparation. In silviculture projects, ground applications normally constitute less than 20 percent of the total area treated by BLM.

Methods of herbicide application in BLM ground-based operations are similar to those of the Forest Service. Ground application in BLM projects is accomplished through backpack spraying, vehicle-mounted spraying, injection, stump treatment, and other hand application methods.

Triclopyr, glyphosate, atrazine, and dalapon accounted for more than 95 percent of the total herbicides chosen for site preparation operations under the proposed alternative of the EIS for the **Western Oregon Program--Management of Competing Vegetation** (1983). These four herbicides and 2,4-D accounted for nearly 90 percent of the herbicides selected for use in the maintenance and release projects under the proposed alternative for BLM's silviculture program. BLM's right-of-way maintenance projects used triclopyr, 2,4-D, dicamba, and diuron for almost all of the acres treated. BLM's ground spraying projects are about the same size as the Forest Service's.

Mitigation Measures

Mitigation measures are intended to ensure the proper and safe application of herbicides on Forest Service and BLM lands in Washington and Oregon and are required by Federal, State, and regional procedures. Federal and State laws and regulations set minimum standards to be followed during herbicide application on forests and rangelands owned by the Federal Government. Each regional and district office also may develop additional restrictions and precautions. The Federal Insecticide, Fungicide, and Rodenticide Act requires that pesticide manufacturers register their chemicals with the U.S. Government and list the allowable uses, application rates, and special restrictions on the herbicide's label. All of the herbicides considered in this risk assessment are registered with the Environmental Protection Agency; and their label rates, uses, and handling instructions must be complied with according to Federal law.

The Department of the Interior (Bureau of Land Management) and the Department of Agriculture (Forest Service) have handbooks that prescribe guidelines for aerial and ground application operations. Regional publications, such as BLM's **Western Oregon Program--Management of Competing Vegetation Environmental Impact Statement** and the Forest Service's **Region 6 Vegetation Management Program Environmental Impact Statement**, serve to further refine herbicide application guidelines. The Siskiyou National Forest **Aerial Applicator's Handbook** (USDA, 1982) is an example of a forest level operational guideline that specifies detailed herbicide application procedures.

Aerial and ground application procedures undergo detailed planning weeks or even months in advance. Mitigation measures, such as not spraying in sensitive areas, notifying the public, posting warning signs, and conducting water monitoring, are specified in site-specific annual vegetation management plans.

Many mitigation measures developed for herbicide operations in Washington and Oregon are described in each agency's environmental impact statements, which this document supplements. Some specific examples of project mitigation measures include the following:

1. Application operations will be suspended when any of the following conditions exist:

   a. Wind velocity exceeds 5 miles per hour
   b. Air temperature exceeds 70 °F
   c. Relative humidity is less than 50 percent
   d. It is raining or misting or there is a 40-percent chance of rain within several hours
   e. Foggy weather

2. During air operations, a radio network will be maintained to link all parts of the project.

3. Equipment is designed to deliver a median droplet diameter of 200 to 800 microns. This droplet size is large enough to avoid excessive drift while providing adequate coverage of target vegetation.

4. Individuals invoived in the herbicide handling or application will be instructed on the safety plan and spill procedures.

Section 3
Hazard Analysis

Introduction

This section presents the results of the hazard analysis: a review of available toxicological information on the 16 herbicides—amitrole, asulam, atrazine, bromacil, 2,4-D, 2,4-DP, dalapon, dicamba, diuron, fosamine, glyphosate, hexazinone, picloram, simazine, tebuthiluron, and triclopyr—that are to be used in the Forest Service and BLM vegetation management programs in the Pacific Northwest. The first subsection describes the sources of toxicity information used in the hazard analysis. The second subsection explains the terminology concerning laboratory toxicity testing used later in describing the toxic properties of the 16 herbicides. The third subsection presents summaries of the threshold toxicity of each herbicide drawn from the information that was available. The fourth and fifth subsections describe the potential for each of the 16 herbicides to cause the nonthreshold effects of genetic mutations and cancer, respectively. The final subsection presents the details of the derivation of cancer potency for those herbicides suspected of being carcinogenic.

Sources of Toxicity Information

The toxicity of 12 of the herbicides (amitrole, atrazine, 2,4-D, 2,4-DP, dalapon, dicamba, fosamine, glyphosate, hexazinone, picloram, simazine, and triclopyr) to both laboratory animals and humans is described in detail in the background statements of the Forest Service Agricultural Handbook No. 633 (USDA, 1984). Tebuthiuron toxicity is described in a background statement prepared for the Forest Service as a supplement to Handbook No. 633. The toxicity of the herbicides asulam, diuron, and bromacil is described in background statements written in conjunction with this risk assessment. These documents are incorporated by reference into this Supplement to the Final Forest Service and BLM EIS's identified in Section 1 in accordance with 40 CFR 1502.16 and are available for review at all Forest Service and BLM District Offices in Oregon and Washington, as well as at the address shown on the cover page.

Much of the data on pesticide toxicity have been generated to comply with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq), which establishes procedures for the registration, classification, and regulation of all pesticides, including herbicides. EPA is responsible for implementing FIFRA. Toxicity levels and related information from the series of studies submitted for registration are compiled by EPA in summary tables called "tox one-liners" that are available on request from EPA's Freedom of Information Office. EPA has compiled "science chapters"' on many of the herbicides (amitrole, bromacil, dicamba, diuron, hexazinone, picloram, and simazine) and these are also available from EPA. A large body of additional toxicity information exists in the open literature, particularly for chemicals such as 2,4-D that have been used for many years.

An extensive literature search was funded by the U.S. Department of Agriculture, Forest Service, to ensure that all of the relevant available information was used in this risk analysis. The Medline data base, the Embase (Excerpta Medica) data base, and the International Pharmaceutical Abstract data base were searched to locate current literature pertaining to the carcinogenicity and mutagenicity of the herbicides.

The data from the U.S. Department of Agriculture, Forest Service, Pesticide Background Statements (1984) were reviewed and compared to summaries of studies submitted to the Environmental Protection Agency for the registration of the 16 herbicides. Whenever possible, studies that have been reviewed and validated by EPA were used to set toxicity reference levels. In no cases were studies used that have been invalidated by EPA.

Hazard Analysis Terminology

Because of obvious limitations on the testing of chemicals on humans, judgments about the potential hazards of pesticides to humans are necessarily based on the results of toxicity tests on laboratory animals. These toxicity test results are supplemented by information on actual human poisoning incidents and effects on human populations when they are available. The discussion of laboratory toxicity testing that follows is drawn from Hayes (1982), Doull et al. (1980), and Loomis (1978).

Laboratory Toxicity Testing

Test Animal Species

Laboratory test animals function as models of the likely effects of the pesticide in humans. Ideally, the test animal should metabolize the compound the same as a human would and should have the same

susceptible organ systems. Results of such tests then can be directly extrapolated to humans with some adjustment made for differences in body weight and body surface area. Although no test animal has proven ideal, a number of species have proven to be consistent indicators for certain types of toxicity tests, routes of administration, and types of chemicals; in particular, rats, mice, rabbits, hamsters, guinea pigs, dogs, and monkeys.

Toxic Endpoints and Toxicity Reference Levels

Toxicity tests are designed to produce specific toxic endpoints, such as fatality or cancer, and toxicity reference levels, such as a no-effect level. In addition to the test animal used, toxicity tests vary according to test duration, route of administration, dose levels, dosing schedule, number of test groups, and number of animals per group. Toxicity tests also vary on the basis of whether it is assumed that the effect in question is a threshold effect or a nonthreshold effect.

Threshold and Nonthreshold Effects

Most chemicals are assumed to have a threshold level of toxic effects on a local basis (at the site of administration) or systemic basis (acting throughout the body), below which no adverse effects occur to the test organism. Chemicals are generally thought to possess no such threshold level for cancer and mutations, thus these toxic endpoints may occur (with a certain level of probability) even in the presence of extremely small quantities of the substance. In this hazard analysis, threshold effects are discussed first, in the following subsection. The nonthreshold effects, mutagenicity and cancer, are discussed in the last two subsections.

Duration of Toxicity Tests

The duration of toxicity tests ranges from very short-term acute tests to longer subchronic studies to chronic studies that may last the lifetime of an animal. Acute toxicity studies involve administration of a single dose to each member of a test group (either at one time or in a cumulative series over a short period of less than 24 hours). Subchronic toxicity studies, used to determine the effects of multiple doses, usually last from a few days to 3 months (3 to 90 days) but generally less than one-half the lifetime of the test animal. Chronic studies, also used to determine the effects of multiple or continuous doses, normally last 2 to 7 years but generally more than one-half the test species' lifetime.

Routes of Administration

Routes of administration include oral via gavage (forced into the stomach with a syringe through a plastic tube) or fed in the diet, dermal (applied to the skin), inhalation (through exposure to vapors or aerosol particles), and parenteral (injection other than into the intestine) routes, such as subcutaneous (SC), which means injected under the skin, intraperitoneal (IP), meaning injected into the abdominal cavity, and intravenous (IV), meaning injected into a vein. Oral, dermal, and inhalation doses most nearly duplicate the likely routes of exposure to humans. Parenteral doses are used in testing drugs but are not widely used in toxicity testing of pesticides because they bypass the test animal's natural protective mechanisms. Doses are expressed in several ways. They can be expressed as milligrams (mg, which is 1/1,000 of a gram) of the chemical per kilogram (kg, which is 1,000 grams) of body weight of the test animal, or in parts per million (ppm) in the animal's diet, or in milligrams per liter (mg/L) in the air the animal breathes.

Dosing Levels

Dosing in longer term studies is generally done through the diet with specified amounts in parts per million in the food. The known weight of the test animals over the test period is used to convert ppm in the diet to milligrams of chemical per kilogram of body weight per day (mg/kg/day) for extrapolation to humans. Generally, at least three dosing levels are used in addition to a zero dose or control group. Animals of each sex usually are dosed in groups of 8 to 50.

Types of Toxicity Studies

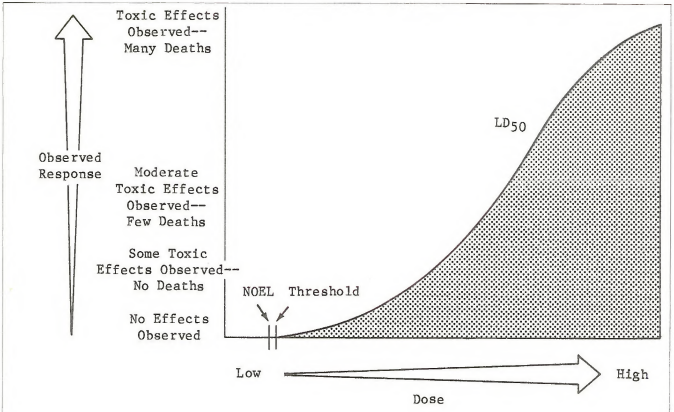
Acute Toxicity Studies

Acute toxicity studies are used to determine the toxicity reference level known as the median lethal dose (LD_{50}), which is the dose that kills 50 percent of the test animals. The lower the LD_{50}, the greater the toxicity of the chemical. The LD_{50} ranges and toxicity categories used in this risk assessment are those of the EPA classification system using rat LD_{50}'s, as shown in Table 3-1 (adapted from Walstad and Dost, 1984). Because lethality is the intended toxic endpoint, dose levels usually are set relatively high in acute studies. Toxic symptoms displayed by the animals are recorded throughout the study, and tissues and organs are examined for abnormalities at the end of the test. The animal most commonly used for oral LD_{50}'s is the rat. Rabbits are used most often to determine dermal LD_{50}'s.

Table 3-1
Acute Toxicity Classification and Acute Toxicities of the 16 Herbicides and Other Chemicals

Toxicity Category[1] (label signal words)	Herbicide or Other Chemical Substance	Oral LD_{50} for Rats (mg/kg)	Equivalent Human Dose
IV Very slight		5,000 - 50,000 (range)	More than 1 pint
	Sugar	30,000	
	Fosamine	24,400	
	Ethyl alcohol	13,700	
	Picloram	8,200	
	Dalapon	7,577	
III Slight (caution)		500 - 5,000 (range)	1 ounce to 1 pint
	Simazine	5,000	
	Glyphosate	4,320	
	Amitrole	4,080	
	Asulam	4,000	
	Bromacil	3,998	
	Table salt, Diuron	3,750	
	Bleach	2,000	
	Atrazine	1,869	
	Aspirin, Vitamin B_3	1,700	
	Hexazinone	1,690	
	Dicamba	757	
	Tebuthiuron	644	
	Triclopyr	630	
	2,4-DP	532	
II Moderate (warning)		50 - 500 (range)	1 teaspoon to 1 ounce
	2,4,5-T	500	
	2,4-D	375	
	Caffeine	200	
	DDT	100	
I Severe (danger - poison)		0 - 50 (range)	1 teaspoon or less
	Nicotine	50	
	Strychnine (rodenticide)	30	
	Parathion (insecticide)	13	
	TCDD (dioxin)	0.001	
	Botulinus Toxin	0.00001	

[1]Categories, signal words, and LD_{50} ranges are based on a classification system used by the EPA for labeling pesticides.
Source: Maxwell, 1982 (as cited in Walstad and Dost, 1984).



LD_{50} - Acute lethal dose. One-time or short-term dose that is lethal to 50 percent of treated animals.

Threshold - Dose level at which toxic effects are first observed in test animals.

NOEL - No-observed-effect level. Long-term dose that does not result in apparent adverse effects in test animals.

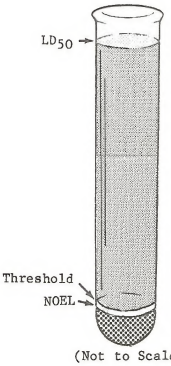


Figure 3-1 Relationships Among Toxicity Reference Levels

Because death represents the extreme toxic consequence for judging possible effects from the use of pesticides, the policies of regulating agencies regarding acceptable intake levels of these chemical compounds are most often based not on acute studies, but rather on toxicity tests designed to find the dose level that produces no effects in the animal species tested. Figure 3-1 illustrates the relationship between the LD_{50} and the no-effect level.

Subchronic Toxicity Studies

Subchronic studies are designed to determine the toxicity reference level called the no-observed-effect level (NOEL), which is the highest dose level at which no toxic effects are observed. If a chemical produces effects at the lowest dose tested (LDT) in a study, the NOEL must be at some lower dose. If the chemical produces no effects, even at the highest dose tested (HDT), the NOEL is equal to or greater than the HDT. Another toxic endpoint of interest is the lowest dose showing toxic effects, the lowest effect level (LEL). For local and systemic effects, the chemical's threshold of effect lies between the NOEL and LEL for the tested species (see Figure 3-1).

Subchronic studies, normally employing lower dose levels than acute studies, provide information on systemic effects, cumulative toxicity, the latency period (the time between exposure and the manifestation of a toxic effect), the reversibility of toxic effects, and appropriate dose ranges to be used in chronic tests. The adverse effects may include death; decreased rate of food consumption; change in body weight; decreased enzyme levels; changes in blood constituents, such as red blood cells (RBC's) or white blood cells (WBC's); undesirable constituents in the urine; or microscopic changes in tissues.

Chronic Toxicity Studies

Chronic studies, like subchronic studies, can be used to determine systemic NOEL's. All other things being equal, the longer the study from which the NOEL is derived, the more reliable the resulting value. Chronic studies, however, are even more important in determining doses that are hazardous to reproductive success or in determining whether the chemical causes cancer. Chronic tests include teratogenicity tests, reproduction studies, and carcinogenicity tests.

Teratogenicity tests. Teratogenicity tests (teratology studies) determine the potential of a chemical to cause malformations in an embryo or a developing fetus between the time of conception and birth. These studies generally use rats or rabbits, and they may be conducted over several generations. The animals are monitored for functional as well as structural deformities.

Reproduction studies. Reproduction studies are conducted to determine the effect of the chemical on reproductive success as indicated by fertility (production of reproductive cells), fetotoxicity (direct toxicity to the developing fetus), and survival and weight of offspring. These tests are performed at doses similar to those used in teratogenicity studies and generally use rats. Both male and female rats are exposed to the chemical for a number of weeks before mating. The number of resulting pregnancies, stillbirths, and live births are recorded. Tests may be conducted over two or three generations.

Carcinogenicity tests. Carcinogenicity tests (cancer studies or oncogenicity studies) examine the potential for a chemical to cause cancerous (malignant) tumors when fed in the diet over the animal's lifetime. Testing is normally conducted with rats or mice for a 2-year period.

Mutagenicity Assays

Mutagenicity assays are used to determine the ability of a chemical to cause physical changes (mutations) in the basic genetic material (DNA) that could be passed on from one generation to the next. The species used in these tests range from primitive organisms, such as the bacteria **Salmonella**, **Escherichia**, and **Streptomyces**; the mold **Aspergillus**; the yeast **Saccharomyces**; and the fruit fly **Drosophila**, to the more advanced organisms that include mammalian species. Tests may be conducted in vivo (within the body of the living organism) or in vitro (on cells cultured outside the body in a petri dish or test tube). There are many types of tests in this category, including the dominant lethal assay, which is usually conducted with rodents, and the Ames reverse mutation test, which is conducted with bacteria. The subsection on mutagenicity of the 16 herbicides gives more information about mutagenicity tests.

Threshold Toxicity of the 16 Herbicides

The toxicity reference levels used in this risk assessment to describe both acute and chronic threshold effects of the 16 herbicides are presented in Table 3-2. The LD_{50}'s in this table are from rat oral studies. Two types of NOEL's are given in Table 3-2. The first NOEL is for general systemic effects, such as growth retardation, decreased red blood cell counts, and increased thyroid weight. All of the systemic NOEL's take into account validated 2-year chronic feeding studies. For amitrole, asulam, fosamine, picloram, tebuthiuron, and triclopyr, subchronic study NOEL's were used because they are

Table 3-2
Laboratory-Determined Toxicity Levels Used in the Risk Analysis

Herbicide	Acute Oral LD_{50} in Rats	Lowest Systemic NOEL	Lowest Reproductive and/or Teratogenic NOEL
Amitrole	Greater than 4,080 mg/kg (EPA, 1984a)	0.5 ppm (0.025 mg/kg/day) sub-chronic rat feeding study (EPA, 1985a)	100 ppm (5 mg/kg/day) 2-generation rat reproduction study (EPA, 1985a) No birth defects observed in any stidues. Fetotoxic NOEL = 5,000 ppm (750 mg/kg/day) mouse teratology study (EPA, 1985a)
Asulam	Greater than 4,000 mg/kg (EPA, 1984b)	50 mg/kg/day 107-week rat feeding study (EPA, 1985d)	1,000 ppm (50 mg/kg/day) 2-generation rat reproduction study (EPA, 1984b) Maternal NOEL =300 mg/kg, rabbit teratology study (EPA, 1984b) No birth defects observed in any studies
Simazine	Greater than 5,000 mg/kg (EPA, 1984n)	Greater than 100 ppm (5 mg/kg/day)(HDT), 2-year rat feeding study (EPA, 1984n)	Greater than 100 ppm (5.0 mg/kg/day), (ODT), 3-generation reproduction study (EPA, 1984n)
Tebuthiuron	644 mg/kg (DOE, 1983)	500 ppm (12.5 mg/kg/day), 90-day dog feeding study (EPA, 1975)	No birth defects. Greater than 1,800 ppm (90 mg/kg/day), reproduction rat study (Todd et al., 1974, in USDA, 1985b) 237 mg/kg, dermal teratology study (EPA, 1984o) Reoroductive NOEL greater than 400 ppm (20 mg/kg/day) (HDT) , 2-generation reproduc-tion study with rats (EPA, 1985d)
Triclopyr	630 mg/kg (EPA, 1984p)	2.5 mg/kg/day (HDT), 6-month dog feeding study (40 CFR Part 180, 50 (84):18485, May 1, 1985)	Fetotoxic NOEL less than 10 mg/kg, rabbit teratology study (EPA, 1984p) No teratogenic effects greater than 30 mg/kg (HDT), 3-generation rat reproduction study (USDA, 1984)
Fosamine	24,400 mg/kg (EPA, 1984j)	1,000 ppm (25 mg/kg/day) 6-month dog feeding study (Schneider and Kaplan, 1983 in USDA, 1984)	Greater than 1,000 ppm (750 mg/kg/day), rat teratology study (Schneider and Kaplan in USDA, 1984)
Glophosate	4,320 mg/kg (EPA, 1984k)	Greater than 30 mg/kg/day, 26-month rat feeding study (EPA, 1984k)	10 mg/kg, 3-generation reproduction rat study (EPA, 1984k) Maternal NOEL = 175 mg/kg rabbit teratology study (USDA, 1984). No birth defects

Table 3-2 (cont.)
Laboratory-Determined Toxicity Levels Used in the Risk Analysis

Herbicide	Acute Oral LD_{50} in Rats	Lowest Systemic NOEL	Lowest Reproductive and/or Teratogenic NOEL
Hexazinone	1,690 mg/kg (EPA, 1984l)	200 ppm (10 mg/kg/day) 2-year rat feeding/oncogenic study (EPA, 1984l)	1,000 ppm (50 mg/kg/day), 3-generation reproduction rat study (USDA, 1984) 125 mg/kg (HDT), rabbit teratology study (USDA, 1984)
Picloram	8,200 mg/kg, rat	7, mg/kg, 6-month dog feeding study (Muillison, 1985)	No teratogenic effects in 3 studies 1,000 ppm (50 mg/kg/day), rat 3-gerenation reproduction study (EPA, 1984m)
2,4-DP	532 mg/kg, rat (EPA, 1984f)	50 mg/kg, 2-year rat feeding study (EPA, 1984f) 5 mg/kg 13-week rat feeding study (EPA, 1982)	Three-generation rat reproduction study, NOEL = 125 ppm (6.25 mg/kg/day) (EPA, 1984f) Teratogenic effects at 25 mg/kg/day (LDT). Maternal and fetotoxic NOEL = 25 mg/kg/day, rabbit (EPA, 1984f)
Dalapon	7,577 mg/kg (EPA, 1984g)	15 mg/kg, 2-year rat feeding study (USDA, 1984)	Greater than 300 mg/kg/day, 3-generation rat reproduction (USDA, 1984)
Dicamba	757 mg/kg (USDA, 1984)	500 ppm (25 mg/kg/day) 90-day subchronic feeding study (EPA, 1984h)	No teratogenic effects reported in 4 studies Fetotoxic and maternal NOEL = 3.0 mg/kg/day, rabbit teratology study (EPA, 1984h) Reproductive NOEL = 2.5 mg/kg/day (EPA, 1985d)
Diuron	3,750 mg/kg (EPA, 1984i)	25 ppm (0.625 mg/kg/day) 2-year dog feeding study (EPA, 1984i)	No birth defects. NOEL greater than 125 ppm 3-generation rat reproduction study (6.25 mg/kg/day) (Hodge et al., 1967; EPA, 1984i)
Atrazine	1,869 mg/kg (EPA, 1984c)	150 ppm (3.7 mg/kg/day) 2-year dog feeding study (EPA, 1984c)	No birth defects in two studies Three-generation reproductive NOEL of greater than 100 ppm (50 mg/kg/day), rat (EPA, 1984c) 100 mg/kg/day fetotoxic NOEL rat teratology study (EPA, 1984c)
Bromacil	3,998 mg/kg (EPA, 1984d)	250 ppm (6.25 mg/kg/day), 2-year dog feeding study (EPA, 1984d)	No teratogenic effects in two studies Greater than 165 mg/m³ (7.9 mg/kg/day HDT), rat teratology study (EPA, 1984d)
2,4-D	375 mg/kg (EPA, 1984e)	1.0 mg/kg, first year results from 2-year rat feeding study (EPA, 1985c)	Fetotoxic NOEL = 25 mg/kg/day, rat teratology study (EPA, 1984e)

Conversion Factors:
mouse 1 ppm = 0.150 mg/kg/day
rat (lifetime) 1 ppm = 0.05 mg/kg/day
rabbit 1 ppm = 0.030 mg/kg/day
dog 1 ppm = 0.025 mg/kg/day

Source: USDA, 1984

the lowest NOEL's found in the literature. The second NOEL is for reproductive effects, including infertility, miscarriage, general fetal toxicity, and birth defects (teratogenesis). Where information is available, NOEL's are given for both reproductive and teratogenic effects. All the NOEL's used are the lowest found in validated studies.

The following subsections summarize the most relevant acute and chronic toxicity tests that have been conducted on 16 herbicides. Areas where no validated studies exist or in which EPA has requested additional studies are noted.

Amitrole

Amitrole can be classified as slightly toxic (see Table 3-1) based on the acute oral LD_{50} value in rats of 4,080 mg/kg (EPA, 1984a). The lowest systemic NOEL found in the literature, based on thyroid effects in a subchronic feeding study with rats, was reported to be 0.5 ppm (0.025 mg/kg/day) (EPA, 1985a).

EPA's risk assessment of amitrole (EPA, 1985a) states the following:

> In a subchronic feeding study (Fregly, 1968), male rats were fed 0, 0.25, 0.50, 2.00, 10, and 50 ppm amitrole in the diet for 11 or 13 weeks. Thyroid iodine uptake was reduced, and enlarged thyroids were observed in animals fed 2.00, 10, and 50 ppm. Significant functional changes had already occurred after only 1 week of feeding.
>
> In addition, another subchronic feeding study (Food Drug Research Labs, 1977) fed male rats 0, 30, 100, and 300 ppm amitrole in the diet for 4 weeks followed by 4 weeks on control diet. The study was designed to demonstrate the reversibility of the antithyroid effects of amitrole. Reduced levels of T_3 and T_4 were reported in the 100 and 300 ppm groups after 14 and 7 days, respectively, on the amitrole diets. After 21 days on the control diet during the recovery phase of the study, all treatment groups had T_3 and T_4 values similiar to concurrent control values.
>
> In a 2-generation reproduction study, groups of male and female rats (F_0) were fed 500 and 1,000 ppm amitrole for 107 to 110 days. Two other groups were fed 25 and 100 ppm for 240 to 247 days, and their progeny (F_1) were fed 25 and 100 ppm amitrole for 141 days (Gaines, 1973). Pups born to parents fed 500 and 1,000 ppm amitrole were small, and had atopic thymuses and spleens indicative of runting; no signs of runting were observed in the 25 and 100 ppm pups. Hyperplasia of the thyroid was observed in all animals fed 25 ppm and higher.
>
> No teratogenic effects were observed at birth through weaning when pregnant rats were orally gavaged from day 7 through 15 of gestation with 20 and 100 mg/kg/day of amitrole (Gaines, 1973). In another teratology study, pregnant mice were treated with 500, 1,000, 2,500, and 5,000 ppm amitrole in the drinking water from day 6 through 18 of gestation (Tjalve, 1974). No teratogenic effects were observed. Indications of fetotoxic effects were observed in the 1,000, 2,500, and 5,000 ppm treatment groups. These effects were small fetuses, underdeveloped fetuses with immature skeletons, and increased number of resorptions (5,000 ppm group only).
>
> The body of nononcogenic data indicates that amitrole has a low acute toxicity in experimental animals. However, amitrole is a potentially potent antithyroid agent as evidenced by the low subchronic feeding levels (2 ppm) that resulted in significant effects on thyroid function. The data also indicate that amitrole does not pose a significant reproductive hazard. However, the data are insufficient to assess teratogenic potential.

EPA has requested additional data to assess the teratogenic potential of amitrole.

Asulam

Based on the acute oral LD_{50} of greater than 4,000 mg/kg in rats (EPA, 1984b), asulam can be classified as slightly toxic (see Table 3-1). The systemic NOEL of 2,000 ppm (100 mg/kg/day) was based on fatty deposits in the liver derived from a 90-day rat feeding study (EPA, 1984b). A 6-month dog feeding study established a NOEL of 60 mg/kg/day (EPA, 1984b). A systemic NOEL of 50 mg/kg/day was determined for a 107-week feeding study with rats (EPA, 1985d).

Teratology and multigeneration reproduction studies indicate that asulam does not cause teratogenic or fetotoxic effects in test animals. A 2-generation rat reproduction study also resulted in the absence of terata and fetotoxic effects at 1,000 ppm (50 mg/kg/day); however, reproductive effects characterized by a decrease in the number of live births were reported at 5,000 ppm (250 mg/kg/day) and 25,000 ppm (1,250 mg/kg/day) (EPA, 1984b). The highest NOEL reported for a rabbit teratology study was 300 mg/kg, with no teratogenic or fetotoxic effects reported (EPA, 1984b). A rat teratology study resulted in the absence of any toxic effects and a NOEL established at greater than 40 mg/kg/day (HDT) (EPA, 1984b).

Atrazine

Atrazine can be classified as a slightly toxic her-

bicide, based on the acute oral LD_{50} of 1,869 mg/kg in rats (EPA, 1984c). A 2-year dog feeding study resulted in the establishment of a systemic NOEL of 150 ppm (3.7 mg/kg/day) based on a decrease in body weight (EPA, 1984c). EPA has requested additional studies on the long-term and oncogenic effects of atrazine. A 3-generation reproduction study in rats reported no reproductive or systemic effects at the highest dose tested (100 ppm or 5 mg/kg/day) (EPA, 1984c). Fetotoxic effects characterized as weight loss and fetal resorptions occurred at a dose level of 500 mg/kg in a rat teratology study (EPA, 1984c). A mouse teratology study reported no significant increases in fetal abnormalities at 46.4 mg/kg (Hayes, 1982).

Bromacil

Based on the acute oral LD_{50} of 3,998 mg/kg in rats (EPA, 1984d), bromacil can be classified as slightly toxic. A systemic NOEL of 250 ppm (6.25 mg/kg/day) was derived from a 2-year dog feeding study that indicated decreases in body weights (EPA, 1984d). There have not been any teratogenic or fetotoxic effects reported from teratology studies that established a NOEL greater than 250 ppm (7.5 mg/kg/day) for rabbits and a NOEL greater than 7.92 mg/kg for rats (EPA, 1984d).

2,4-D

2,4-D can be classified as moderately toxic (see Table 3-1) in mammals with an LD_{50} in rats of 375 mg/kg (EPA, 1984e). Acute and chronic toxicity studies in mammals revealed general systemic toxic effects following ingestion of large doses of 2,4-D. Similar clinical symptoms have been observed in human case reports. Even though dermal absorption of 2,4-D is limited, the herbicide has produced peripheral neuropathy in a few individuals after accidental exposure. In several cases the recovery has not been complete (USDA, 1984). A 2-year dog feeding study with dose levels of 2,4-D ranging from 0 to 500 ppm (0 to 12.5 mg/kg) established a systemic NOEL of 12.5 mg/kg/day (HDT) (EPA, 1984e). A systemic NOEL of 1,250 ppm (62.5 mg/kg/day) was established for a 2-year rat feeding study (EPA, 1984e).

Results from the first year of a chronic feeding study on rats have been reviewed by EPA (EPA, 1985c). Based on kidney effects, a NOEL of 1 mg/kg/day was established; the lowest effect level was 5 mg/kg/day. Based on this study using a hundredfold safety factor, EPA has established a provisional ADI of 0.01 mg/kg/day.

The reproductive NOEL of 25 mg/kg/day was based on a study of rats exposed to 2,4-D acid and two esters of 2,4-D. Delayed ossification was the fetotoxic effect reported at 75 mg/kg. There were no teratogenic effects observed in the offspring of rats exposed to 2,4-D.

2,4-DP

2,4-DP can be classified as slightly toxic. Two studies reported LD_{50}'s of 650 mg/kg for mice and 532 mg/kg for rats (EPA, 1984f). A subchronic 90-day rat feeding study established a NOEL of 5 mg/kg. At higher doses, enzymes in the blood, hemoglobin, and kidney and liver weights were affected. A systemic NOEL of 100 mg/kg/day (EPA, 1984f) based on increased liver weights was established for an 18-month mouse feeding study. Two-year feeding studies with rats determined a systemic NOEL of 50 mg/kg/day. At the LEL, all of the following effects were observed: decreased weight gain, decreased hematocrit and red blood cells, chronic prostatitis, and kidney degeneration (EPA, 1984f).

A fetotoxic NOEL of 125 ppm (6.25 mg/kg/day) was reported for a 3-generation rat reproduction study, with increased mortality of pups occurring at 500 ppm (25 mg/kg/day) (EPA, 1984f). A rabbit teratology study determined fetotoxic and maternal NOEL's of 25 mg/kg and a teratogenic NOEL of less than 25 mg/kg, which was the lowest dose tested. Teratogenic effects characterized by displaced kidneys, navel hernia, and distorted ribs occurred at 25 mg/kg in rabbits. Fetotoxic effects such as reduction in fetal weight and reduction in crown-rump distance were reported at a dose level of 100 mg/kg/day in rabbits. Maternal toxic effects such as unsteadiness in gait, reduced food intake, and mortality were also observed at the rabbit dose level of 100 mg/kg/day.

Dalapon

Based on the acute oral LD_{50} of 7,577 mg/kg in the rat (EPA, 1984g), dalapon can be classified as slightly toxic (see Table 3-1). A systemic NOEL of 15 mg/kg/day was reported for a 2-year rat feeding study based on increases in kidney weights (Paynter et al., 1960, as cited in USDA, 1984). A systemic NOEL of 50 mg/kg/day was reported for a 52-week dog feeding study which also indicated an increase in kidney weights (Paynter et al., 1960, as cited in USDA, 1984). Histology sections of test animal tissues revealed no abnormal pathology or evidence of tumorigenesis due to exposure to dalapon (USDA, 1984). The lowest NOEL reported for teratology studies is 300 mg/kg/day for the rat (USDA, 1984). The only toxic effect noted to occur after maternal exposure to dalapon is reduced weight of pups. The Environmental Protection Agency has initiated a data call-in for a reassessment of the reregistration of dalapon (EPA, 1984g).

Dicamba

Based on an acute oral LD_{50} of 757 mg/kg in the rat, dicamba can be classified as slightly toxic (USDA, 1984) (see Table 3-1). A number of subchronic rat studies and one 2-year rat study did not find any adverse effects at the highest dose tested (EPA, 1984h). EPA reports an in-house value of 250 mg/kg/day for systemic effects (EPA, 1985d). EPA has requested additional chronic studies for dicamba. A 90-day subchronic feeding study in rats established a NOEL of 500 ppm (25 mg/kg/day) based on slight liver cell alterations. This NOEL is similar to a NOEL from a chronic mouse study reported in DOE, BPA, 1984 and, because it is more conservative, will be used in this risk analysis. No birth defects were found in a number of rat and rabbit teratology studies, although fetotoxic and maternal toxic effects have been observed in laboratory animals exposed to dicamba. No reproductive effects were observed in two 3-generation rat studies (EPA, 1984h).

Diuron

Based on the acute oral LD_{50} of 3,750 mg/kg (EPA, 1984i), diuron can be classified as slightly toxic (see Table 3-1). A systemic NOEL of 125 ppm (6.25 mg/kg/day) was derived from a 2-year rat feeding study (EPA, 1984i). A systemic NOEL of 25 ppm (0.625 mg/kg/day) was reported for a 2-year dog feeding study (EPA, 1984i). The criteria for the systemic effects were not reported by EPA for either of these studies. A 3-generation rat reproduction study resulted in the absence of any reproductive effects at the only dose tested of 125 ppm (6.25 mg/kg) (EPA, 1984i). In that same study, a systemic NOEL of less than 125 ppm (6.25 mg/kg/day) was established based on body weight depression of litters (EPA, 1984i).

Fosamine

Based on the acute oral LD_{50} of 24,400 mg/kg in the rat for the formulated product (USDA, 1984), fosamine can be classified as very slightly toxic.

A systemic NOEL of 100 ppm (25 mg/kg/day) was reported for a 6-month dog feeding study, with increased stomach weight being the only toxic effect noted (Schneider and Kaplan, 1983, in USDA, 1984). A systemic NOEL between 5,000 and 10,000 ppm (250 mg/kg/day to 500 mg/kg/day) (HDT) was established for a 90-day rat feeding study (Schneider and Kaplan, 1983, in USDA, 1984).

NOEL's of 1,000 ppm (50 mg/kg/day) and 5,000 to 10,000 ppm (250 to 500 mg/kg/day) were reported for rat teratology studies (Schneider and Kaplan, 1983, in USDA, 1984). No fetal toxic, teratogenic, or reproductive toxic effects were observed in either of the teratology studies.

Glyphosate

Based on the acute oral LD_{50} of 4,320 mg/kg (EPA, 1984k) in the rat, glyphosate can be classified as slightly toxic (see Table 3-1). A 26-month rat feeding study found no observable effects, including cancer, at the highest dose tested. Based on this study, EPA established a NOEL of 30 mg/kg/day (HDT) (EPA, 1984k). A 3-generation reproduction study of glyphosate in rats established a NOEL of 10 mg/kg/day (EPA, 1984k). This NOEL was based on renal tubular dilation in the kidneys of the pups; no effects on fertility or reproductive parameters were noted. Based on this study, EPA has established an acceptable daily intake (ADI) level of 0.1 mg/kg/day. Maternal NOEL's for two teratology studies in rats and rabbits were 1,000 mg/kg/day and 175 mg/kg/day, respectively (EPA, 1984k).

Hexazinone

Hexazinone can be classified as slightly toxic based on the acute oral LD_{50} of 1,690 mg/kg (EPA, 1984l). The systemic NOEL based on 2-year mice and rat feeding studies was established as 200 ppm (30 mg/kg/day, mice; 10 mg/kg/ day, rats) (EPA, 1984l). The toxic effects observed during the study were increases in liver size, a localized increase in liver cells, and localized tissue degeneration at the lowest effect level of 2,500 ppm (375 mg/kg mice, 125 mg/kg rats). Twenty mg/kg/day was the lowest NOEL reported for rabbit teratology studies (USDA, 1984). A 3-generation reproduction study established a NOEL of 1,000 ppm (50 mg/kg/day) in rats (USDA, 1984). A rabbit teratology study reported both a terata and fetotoxic NOEL greater than 125 mg/kg (HDT) (EPA, 1984l).

Picloram

Based on the acute oral LD_{50} of 8,200 mg/kg in rats (EPA, 1984m), picloram can be classified as very slightly toxic. A 6-month dog feeding study, during which test animals were exposed to picloram at the dietary levels of 0, 7, 35, and 175 mg/kg/day, resulted in a chronic NOEL of 7 mg/kg/day (Barna-Lloyd et al., 1982, as cited in Mullison, 1985). Increased liver weights were reported at the lowest effect level of 35 mg/kg/day in males (DOW Chemical Company, 1984).

Two chronic feeding studies performed by IBT have been invalidated by EPA (1984m). EPA has asked for additional data on chronic rodent and nonrodent studies.

The lowest reproductive NOEL reported for picloram is 1,000 ppm (50 mg/kg/ day) in rats, with reduced fertility at the lowest effect level of 3,000 ppm (150 mg/kg/day) (EPA, 1984m). In a rat teratology study, minor skeletal abnormalities related to maternal tox-

icity were observed at 750 mg/kg/day. No deformed offspring or adverse effects to development of the newborn offspring were observed at the highest dose tested (1,000 mg/kg). A teratology study using mice as the test species observed no adverse effects on fertility or number of offspring after exposure to 15 mg/kg/day of picloram (USDA, 1984).

Simazine

Based on the acute oral LD_{50} of greater than 5,000 mg/kg in the rat (EPA, 1984n) simazine can be classified as very slightly toxic (see Table 3-1). A systemic NOEL greater than 100 ppm (5 mg/kg/day) (HDT) was reported for a 2-year rat feeding study (EPA, 1984n). A 2-year dog feeding study did not find any overt signs of toxicity at 1,500 mg/kg/day (HDT). EPA, however, has determined that chronic toxicity and oncogenic potential could not be determined from either of these studies. A 3-generation rat reproduction study established a NOEL greater than 100 ppm (5 mg/kg/day); there were no reported teratogenic, fetotoxic, or reproductive effects at the highest dose tested (EPA, 1984n). EPA has requested additional studies on subchronic toxicity, teratogenicity, and chronic toxicity.

Tebuthiuron

Based on the acute oral LD_{50} of 644 mg/kg in rats (Todd et al., 1974, in DOE, 1983), tebuthiuron can be classified as slightly toxic. A systemic NOEL of 554 ppm (83.1 mg/kg/day) (EPA, 1984o) was established from a 119-day mouse feeding study. A systemic NOEL of 500 ppm (12.5 mg/kg/day) was established for a 3-month dog feeding study based on increased thyroid-to-body weight values and increased blood enzyme levels. A reproductive NOEL of greater than 400 ppm (20 mg/kg/day) (HDT) was determined in a 2-generation reproduction study with rats (EPA, 1985d). Tebuthiuron did not produce any terata among the offspring of rats at the highest dose tested of 1,800 ppm (90 mg/kg) (Todd et al., 1974, as cited in USDA, 1985b). A reproductive NOEL of 90 mg/kg/day is used in this risk assessment because neither of the studies reported above showed reproductive effects at the highest doses tested. A dermal teratology study in rats resulted in a NOEL of 237 mg/kg/day (EPA, 1984o).

Triclopyr

With an acute oral LD_{50} ranging from 630 to 729 mg/kg in rats (EPA, 1984p), triclopyr can be classified as slightly toxic (see Table 3-1). A systemic NOEL of 30 mg/kg/day (HDT) was established for both rat and mouse 2-year feeding studies (EPA, 1984p; USDA, 1984). A 228-day dog feeding study resulted in a systemic NOEL of less than 5 mg/kg/day, based on decreased weight gain and food consumption (Dow Chemical Company, 1983, in USDA, 1984). A 6-month feeding study with dogs resulted in a systemic NOEL of 2.5 mg/kg (HDT) (40 CFR Part 180 5(84):18485 May 1, 1985). The effects found in the dog studies are not representative of effects expected in humans because dogs have a limited capacity for organic anion transport in the kidney. Dogs excrete triclopyr at a slower rate than other laboratory animals or humans. The half-life of triclopyr for urinary excretion in dogs is 96 hours as compared to 1.5 hours in rats and 3.1 hours in monkeys. Toxicity may be increased in dogs because of the greater relative retention time of the compound in the animal's body. Therefore, the use of the NOEL from the dog study (the lowest NOEL found in the literature) in this risk assessment is very conservative and tends to overestimate expected effects in humans.

Laboratory results indicate that triclopyr has caused mild fetotoxicity characterized by delayed ossification of the skull in the offspring of rats exposed to 200 mg/kg/day (USDA, 1984). No teratogenic or reproductive toxic effects were observed during a 3-generation rat reproduction study establishing a NOEL of greater than 30 mg/kg/day (HDT) (USDA, 1984). A NOEL less than 25 mg/kg/day was established for a rabbit teratology study in which there were no teratogenic effects reported, but fetotoxic effects were observed at the dose levels of 25, 50, and 100 mg/kg/day (USDA, 1984). A fetotoxic NOEL of less than or equal to 10 mg/kg was established in a study with rabbits (EPA, 1984p).

Mutagenicity of the 16 Herbicides

This subsection presents a review of the currently available information on the mutagenic hazard of the 16 herbicides. Table 3-3 summarizes the validated tests on each of the 16 herbicides for each category of testing recommended by EPA in their guidance documents on mutagenicity (EPA, 1978 and EPA, 1984r). Table 3-3 also presents the relevance of the recommended tests to a determination of human mutagenic potential according to Dr. David Brusick (see Section 6).

In general, the most reliable mutagenic assays are in vivo cell studies and germ cell or gonadal studies (e.g., **Drosophila** fruit fly sex-linked recessive studies). A germ cell study is considered relevant to evaluating the mutagenicity of a chemical even if the test organism is not mammalian. In vitro studies using mammalian cells are of less importance because of the high percentage of false positive findings induced as a result of interactions between the cultured cells and media conditions. Tests for detecting primary DNA damage (Group 3 in Table 3-3) are not useful in determining the human mutagenic potential of a chemical.

Table 3-3
Mutagenicity Testing on the 16 Herbicides[a]

Mutagenicity Test Type [c]		Value in Determining Human Mutagenicity[b]	Herbicide												
			Amitrole	Asulam	Atrazine	2,4-D	2,4-DP	Dicamba	Fosamine	Glyphosate	Hexazinone	Picloram	Simazine	Tebuthiron	Triclopyr
Group 1–	Tests for detecting gene mutations														
A.	Bacteria with and without metabolic activation	I	2(+)/6(-)	1(-)	3(+)/7(-)	2(+)/13(-)	4(-)	3(-)	1(-)	3(-)	2(-)	1(+)/5(-)	9(-)	1(-)	1(-)
B.	Eukaryotic microorganisms with and without metabolic activation	I			3(-)	1(+)/1(-)	1(+)			1(-)		3(-)			
C.	Insects (e.g., sex-linked recessive lethal test)	II	3(-)		1(+)/1(-)	1(+)/1(-)							2(+)		
D.	Mammalian somatic cells in culture with and without metabolic activation	II		1(-)	1(+)				1(-)	1(-)	1(-)			1(+)	
E.	Mouse specific locus test in vivo	II													
Group 2–	Tests for detecting chromosomal aberrations														
A.	Cytogenetic tests in mammals in vivo	II	2(-)		2(+)	1(+)/1(-)			1(-)		1(-)	1(-)			
B.	Insect tests for heritable chromosomal effects in vivo	II													
C.	Dominant-lethal effects in rodents, heritable translocation tests in rodents, and in vitro cytogenetic assays in mammals	II	4(+)	1(-)	1(+)/3(-)	2(-)		1(-)	1(+)	2(-)	1(+)				1(+)/2(-)
Group 3–	Tests for detecting primary DNA damage														
A.	DNA repair in bacteria (including differential killing of DNA repair defective strains) with and without metabolic activation	NA				2(+)	2(+)								1(-)
B.	Unscheduled DNA repair synthesis in mammalian somatic cells in culture, with and without metabolic activation	NA			1(+)	2(-)		1(-)	1(-)	1(-)	1(-)		1(-)		
C.	Mitotic recombination and gene conversion in yeast, with and without metabolic activation	NA			3(+)/6(-)	2(+)/3(-)	1(+)	1(-)					2(-)		
D.	Sister-chromatid exchange in mammalian cells in culture, with and without metabolic activation	NA	2(-)		1(-)	1(+)								*	

[a]No validated mutagenicity studies are available for bromacil, dalapon, and diuron.
[b]Value in Determining Human Mutagenicity Source: USDA, 1985a
[c]Source: FIFRA, Environmental Protection Agency: Proposed Guidelines for registering pesticides in the U.S. Hazard Evaluation: humans and domestic animals. Fed. Reg. 43:37335-37403, August 22, 1978.
NA – Not Applicable
I – Applicable
II – Greater applicability
* – Inconclusive
\+ - Positive results in Assays
— - Negative results in Assays
Source for Mutagenicity Data: USDA, 1984; EPA, 1985d

For some of the herbicides, no validated mutagenicity tests exist or the mutagenicity tests conducted are insufficient to conclude whether the chemical is mutagenic. For these herbicides, the worst case analysis presented in Section 5 assumed that these herbicides are mutagenic. In these cases the results of carcinogenicity tests (see Table 3-4) were used to estimate mutagenic risk.

Details of the mutagenicity testing on the 16 herbicides are presented in Attachment A.

Amitrole

Amitrole did not produce mutagenic effects in 56 bacterial assays. Positive results were observed in two tests in an unvalidated system with unusual bacteria. EPA has determined that amitrole does not present a potential for genetic effects. The chemical induced transformations in four in vitro assays with mammalian cells (EPA, 1985a). EPA has stated that these results support cancer potential, but not necessarily mutagenic potential.

Asulam

There is no evidence to indicate that asulam has mutagenic potential. Asulam was nonmutagenic when tested in a bacterial assay and assays using mammalian cells in vitro and in vivo (EPA, 1984b).

Atrazine

Atrazine was positive for mutagenicity in eight gene

Table 3-4
Summary of Mutagenicity and Carcinogenicity of Pesticides

Herbicide	Mutagenicity	Carcinogenicity
Amitrole	Nonmutagenic 63/69 assays (USDA, 1984) Amitrole does not present potential for heritable genetic effects (EPA, 1985a)	A probable human carcinogen (EPA, 1985a)
Asulam	Nonmutagenic in 3 assays (EPA, 1984b)	Oncogenic in 1 study (EPA, 1985d). Nononcogenic at HDT in 2 studies (EPA, 1984b)
Atrazine	Mutagenic in 15/33 assays (EPA, 1984c)	Nononcogenic in 2 studies (EPA, 1984c)
Bromacil	No validated studies reported (USDA, 1984; EPA, 1984d)	Oncogenic in 1/2 studies (EPA, 1984d; EPA, 1985e)
2,4-D	Nonmutagenic in 23/31 assays (USDA, 1984)	Nononcogenic in 2 studies (EPA, 1984e) Scientific Uncertainty (Rueber, 1979, as cited in BLM, 1985)
2,4-DP	Nonmutagenic in 4/8 assays (EPA, 1984f)	Oncogenic in 1/3 studies (EPA, 1984f)
Dalapon	No studies reported (EPA, 1984g; USDA, 1984)	Nononcogenic in 2 studies (USDA, 1984);
Dicamba	Nonmutagenic in 6/8 assays (USDA, 1984)	Nononcogenic in 2 studies (EPA, 1984h); Studies not adequate according to EPA (EPA, 1985d).
Diuron	No studies reported (EPA 1984i; USDA, 1984)	Nononcogenic in 2 studies (EPA, 1984i); Studies not adequate according to EPA (EPA, 1985d).
Fosamine	Nonmutagenic in 4/5 assays (USDA, 1984)	Nononcogenic in 3 subchronic studies (EPA, 1984j; USDA, 1984)
Glyphosate	Nonmutagenic in 8 assays (EPA, 1984k)	Nononcogenic in 1 study at HDT (EPA, 1984k). Possibility of weak oncogenic effect in mouse study (EPA, 1985b)
Hexazinone	Nonmutagenic in 5/6 test systems (USDA, 1984)	Nononcogenic in 2 studies (EPA, 1984l)
Picloram	Nonmutagenic in 9/10 assays (USDA, 1984)	Nononcogenic in 3/5 studies (EPA, 1984m; Mullison, 1985)
Simazine	Nonmutagenic in 12/14 studies, (USDA, 1984)	Nononcogenic in 1 study (EPA, 1984n)
Tebuthiuron	Nonmutagenic in 1/2 studies, (EPA, 1985d)	Nononcogenic in 1 study (EPA, 1984o)
Triclopyr	Nonmutagenic in 4/5 bacterial and cytogenetic assays (USDA, 1984; EPA, 1985d)	Nononcogenic in 3 studies (USDA, 1984)

mutation studies and negative in eight others. Three of these positive responses were in tests with the fruit fly that measured gene mutations in germ cells. Positive results were also obtained in tests with mice which measured chromosome alterations in germ cells. Positive responses in these types of assays indicate a potential for mutagenic hazard. Chromosome aberrations in bone marrow cells in vivo support this conclusion. However, these in vivo responses were observed only at very high levels of atrazine equal to or exceeding 1.5 gm/kg (USDA, 1984). Although these results show that atrazine must be viewed as mutagenic at high levels of exposure, the degree of hazard to humans from low levels of exposure would be minimal.

Bromacil

The mutagenicity studies submitted for the registration of bromacil were deemed unacceptable by EPA, and no other validated mutagenicity studies have been completed (EPA, 1984d). Bromacil is probably nonmutagenic because it has been shown to be nononcogenic in a 2-year cancer study with rats (EPA 1984d). The worst case assumption is that bromacil is mutagenic.

2,4-D

Mutagenicity studies on 2,4-D have indicated negative, weakly positive, and positive results for various test systems. Newton and Dost (1981) concluded that 2,4-D may be a weak mutagen but that it is "without significance as an environmental mutagenic hazard." EPA has requested additional data to evaluate the mutagenic potential of 2,4-D in mammalian test systems. The worst case assumption is that 2,4-D is mutagenic.

2,4-DP

A limited assessment of the genotoxicity of 2,4-DP is available. 2,4-DP was nonmutagenic when tested in three nonactivated microbial assays (EPA, 1984f). 2,4-DP was not mutagenic in the Ames test. A bacterial assay was positive for induction of repairable DNA damage with metabolic activation. Positive results were obtained when 2,4-DP was tested in two studies with yeast and a bacterial assay for unscheduled DNA synthesis (EPA, 1984f).

Based on the above data, it cannot be presumed that there is mutagenic hazard because in vitro or submammalian assays are inappropriate for hazard assessment. Based upon the inconsistent genotoxic responses and the reported negative oncogenicity in chronic studies in mice and rats, 2,4-DP represents a negligible mutagenic risk for humans. However, the worst case assumption is that 2,4-DP is mutagenic.

Dalapon

There are no validated mutagenic data on dalapon. The Environmental Protection Agency has initiated a data call-in including mutagenicity testing for a reassessment of the reregistration of dalapon (EPA, 1984g). Dalapon is probably not a mutagen because a 2-year cancer study resulted in no oncogenic effects. However, the worst case assumption is that dalapon has the potential to cause mutagenic effects.

Dicamba

Dicamba was nonmutagenic when tested in various microbial assay systems and a dominant lethal assay with mice (USDA, 1984). It is concluded that dicamba is nonmutagenic.

Diuron

There are no validated mutagenic studies on diuron. EPA has requested additional studies in this area. Diuron was shown to be nonocogenic in a long-term study; therefore it is not likely to be mutagenic. However, the worst case assumption is that dalapon has the potential to produce mutagenic effects.

Fosamine

Fosamine was nonmutagenic when tested in bacterial assay systems, a cytogenetic assay using mammalian cells in vivo, and a DNA assay using mammalian cells in vitro (Schneider and Kaplan, 1983, as cited in USDA, 1984). Chromosome damage was induced by fosamine in an in vitro chromosome assay with rodent cells (Schneider and Kaplan, 1983, in USDA, 1984). Overall, fosamine is considered nonmutagenic and presents no mutagenic hazard to humans.

Glyphosate

Glyphosate was nonmutagenic in microbial assays and mammalian cell assay systems both in vitro and in vivo (EPA, 1984k). There is no evidence to indicate that it is mutagenic or presents any mutagenic risk to humans.

Hexazinone

Negative results were obtained from five of six mutagenicity test systems. Hexazinone was nonmutagenic in Ames assays, an in vitro mammalian cell assay, an assay of unscheduled DNA repair synthesis in mammalian somatic cells, and a mammalian cytogenetic assay (EPA, 1984l; USDA, 1984). Hexazinone was positive for inducing chromosome damage in an in vitro cytogenetic assay with rodent cells (USDA, 1984). This positive

effect was observed only at very high levels and could be caused by a secondary effect, such as high iodine concentrations or pH. Based on these results, hexazinone is determined not to present mutagenic hazard to humans.

Picloram

Picloram was nonmutagenic in microbial assay systems and in the rat in vivo cytogenetic assay (USDA, 1984, and EPA, 1984m). Picloram was mutagenic in one assay on a previously untried system (USDA, 1984). The test used has not been validated for use in the standard battery of tests for mutagenicity. EPA has determined that the positive study was insensitive and not capable of determining mutagenicity in the test system. There is no evidence to conclude that it presents a mutagenic risk to humans. EPA has requested additional picloram mutagenicity studies. The worst case assumption is that it is a mutagen.

Simazine

None of the available mutagenicity studies have been validated by EPA (EPA, 1985d). Simazine was negative for mutagenicity when tested in microbial assay systems and in an in vitro mammalian DNA assay (USDA, 1984). A weakly mutagenic response and an increase in dominant lethals resulted from two studies with the fruit fly (USDA, 1984). This indicates that simazine may be mutagenic in some test systems, but there is no evidence to suggest that it is a mutagenic hazard to humans.

Tebuthiuron

Tebuthiuron tested negative in one mutagenicity assay with bacteria and was weakly positive in a mammalian somatic cell test. Tebuthiuron was nononcogenic in long-term laboratory studies and therefore is probably not a human mutagen. However, the worst case assumption is that tebuthiuron does have potential to cause mutagenic effects.

Triclopyr

Triclopyr was nonmutagenic in microbial assay systems and in a dominant lethal study using mice. A dominant lethal assay with rats was weakly mutagenic (USDA, 1984). Triclopyr may be mutagenic in some test systems, but there is no data to suggest that it is a human mutagen.

Carcinogenicity of the 16 Herbicides

The following discussion summarizes the results of cancer tests and other chronic tests that have been used to determine whether any of the 16 herbicides is carcinogenic. Table 3-4 presents a summary listing of those results.

For those herbicides that have had extensive cancer testing or for which there is scientific controversy concerning the results of one or more cancer studies, the details of the cancer testing are presented in Attachment A. The next subsection on cancer potency summarizes the results of the analysis of tumor data on the five herbicides that have tested positive in at least one cancer study: amitrole, 2,4-D, 2,4-DP, glyphosate, and picloram.

Amitrole Carcinogenicity

The many lifetime laboratory animal feeding studies on amitrole have consistently demonstrated its oncogenic potential. In feeding studies using rats, the thyroid and pituitary were the primary target organs at doses as low as 1/20 ppm amitrole (Food Drug Research Lab, 1981, as cited in EPA, 1985a). In mice, amitrole's oncogenic potential has not been as clearly demonstrated because liver and thyroid tumors occurred only when doses exceeded 2,000 ppm (Innes et al., 1969).

In a 2-year study comparing three animal species, doses of 100 ppm amitrole in the diet produced an increased incidence of thyroid tumors in rats but not in mice or hamsters (Steinhoff, 1983, as cited in EPA, 1985a). In addition, positive results in mice and hamster in vitro cell transformation studies have demonstrated amitrole's carcinogenic potential. Based on the available evidence, EPA has classified amitrole as a "probable human carcinogen." The epidemiological studies on humans do not qualify as "at least limited evidence of carcinogenicity to humans" because the authors' follow-up evaluation is entirely inconclusive. Thus, a higher classification is not warranted (EPA, 1985a). An analysis of its cancer potency is given in the next subsection.

Asulam Carcinogenicity

Asulam was carcinogenic in one of the three oncogenicity studies conducted. No oncogenic effects were observed at doses of asulam up to 5,000 ppm (750 mg/kg/day), the highest dose tested, in two 18-month mouse oncogenicity studies (EPA, 1984b). A statistically significant increase in thyroid cell carcinomas was observed in a rat study at 1,000 ppm (20 mg/kg/day) (EPA, 1985d).

Atrazine Carcinogenicity

Available data do not indicate that atrazine is carcinogenic. In an 18-month mouse feeding study, atrazine did not induce any tumors at 12.5 mg/kg/day (Innes et al., 1969). EPA has requested

additional oncogenic studies on atrazine.

A formulated mixture of atrazine and simazine (Fogard-S) injected into mice produced malignant tumors of the lymph glands. However, because there were many flaws in this study and it is not possible to distinguish what caused the tumors, this study is not considered substantive evidence for carcinogenicity in atrazine. In addition, there is no reason to conclude that a carcinogenic nitrogen derivative of atrazine, N-Nitrosoatrazine (NNA), would be formed in toxic quantities in exposure of humans to atrazine. Details concerning Fogard-S and NNA are given in Attachment C.

Bromacil Carcinogenicity

Bromacil was carcinogenic in one of two oncogenicity studies conducted. No oncogenic effects were observed in rats as a result of exposure to bromacil for a 2-year test period (EPA, 1984d). Liver tumors in mice were observed at 5,000 ppm (750 mg/kg/day) after 18 months of exposure (EPA, 1985e).

2,4-D Carcinogenicity

A number of studies have assessed the carcinogenicity of 2,4-D, and thus far, there are no conclusive data demonstrating the carcinogenicity of 2,4-D (International Agency for Research on Cancer, 1977; Mullison, 1981; State of Minnesota, 1978, all as cited in USDA, 1984). However, there is also general agreement that none of these studies were adequate (EPA, 1982a; International Agency for Research on Cancer, 1977, as cited in USDA, 1984; WHO, 1984). At least one scientist, Dr. M. Rueber, disputes the conclusion that a carcinogenic effect of 2,4-D has not been shown. A long-term oncogenicity study requested by EPA is not due to be submitted until 1986, when it will be reviewed by that agency (Rueber, 1979, as cited in BLM, 1985). In view of this uncertainty, a cancer risk analysis was conducted in this risk assessment under the assumption that 2,4-D is carcinogenic.

2,4-DP Carcinogenicity

Available evidence indicates that 2,4-DP is carcinogenic in rats (EPA, 1982b). Two-year feeding studies with rats showed tumor formation occurred at doses as low as 25 mg/kg/day (EPA, 1984f). At all doses tested (25, 50, or 150 mg/kg), malignant tumors were induced in test animals. Another study using mice as the test species showed no oncogenic effects at the highest dose tested (300 mg/kg/day) (EPA, 1984f). 2,4-DP is assumed to be a human carcinogen for the purposes of this analysis, and a risk assessment is presented in Section 5. 2,4-DP's cancer potency is discussed in the next subsection.

Dalapon Carcinogenicity

Available data do not indicate that dalapon is carcinogenic. In a 2-year rat feeding study (Paynter et al. 1960 as cited in USDA, 1984) and a 52-week dog feeding study (Paynter et al. 1960 as cited in USDA, 1984), histology sections of test animal tissues revealed no abnormal pathology or evidence of tumor formation resulting from exposure to dalapon (USDA, 1984).

Dicamba Carcinogenicity

Available evidence does not indicate that dicamba is carcinogenic. A 2-year rat feeding study resulted in the absence of any toxic or oncogenic effects of dicamba at 500 ppm (25 mg/kg/day) (HDT). This study is graded as supplementary data by EPA (EPA, 1984h). EPA has requested additional cancer studies for dicamba because the available studies are not considered adequate for defining the oncogenic potential of dicamba based on EPA guidelines under FIFRA (EPA, 1985d).

Diuron Carcinogenicity

Available evidence does not indicate that diuron is carcinogenic. At levels as high as 2,500 ppm, there was an absence of oncogenic effects in test animals exposed to diuron (Hodge et al., 1967; DOE, 1983). EPA has requested additional cancer studies on diuron to adequately determine the cancer potential of diuron under the current FIFRA guidelines.

Fosamine Carcinogenicity

Available evidence does not indicate that fosamine is carcinogenic. In a 6-month dog feeding study no oncogenic effects were observed (Schneider and Kaplan, 1983, in USDA, 1984). A 90-day rat feeding study showed no oncogenic effects (Schneider and Kaplan, 1983, in USDA, 1984). Neither the dosage levels administered nor the dosage levels at which toxic effects occurred were reported in 2-year feeding studies to evaluate the oncogenic potential of fosamine.

Glyphosate Carcinogenicity

EPA is currently reviewing the results from a chronic mouse study, which in EPA's opinion indicate that glyphosate may be a weak oncogen. Monsanto claims that the data indicate no evidence of carcinogenicity in male or female rats and female mice. Also, extensive mutagenic testing has proven negative. They dispute whether the new data on male mice is statistically significant. Dr. Edward Calabrese (see list of preparers) has reviewed both EPA's and Monsanto's findings and believes that no final decision on the cancer potential of

glyphosate can be reached until a number of issues have been resolved. For the purposes of this risk analysis, a worst case assumption is made that glyphosate is a carcinogen, and a risk assessment was conducted. Details of this positive study and EPA's position are presented in Attachment A. Glyphosate's cancer potency is discussed in the next subsection and in Attachment A.

A carcinogenic nitrogen derivative of glyphosate, N-Nitrosoglyphosate (NNG), is not considered a potential human hazard here because NNG is not likely to form in soils at the application rates used in forestry. Details concerning NNG are presented in Attachment A.

Hexazinone Carcinogenicity

Available evidence does not indicate that hexazinone is carcinogenic. In 2-year mouse and rat feeding studies no oncogenic effects of hexazinone were observed at any of the doses tested (200, 1,000, and 2,500 ppm in rats, and at the testing levels of 200, 2,500, and 10,000 ppm in mice) (EPA, 1984l).

Picloram Carcinogenicity

There has been disagreement among experts on the interpretation of studies about the potential of picloram to cause cancer. A rat oncogenicity study, in which test animals were exposed to an average of 14,875 ppm (743 mg/kg/ day), was negative for oncogenic effects in males. However, liver tumors were observed in females (EPA, 1984q). A mouse oncogenicity study showed no tumor formation at dietary exposure levels ranging from 5,000 to 15,000 ppm (750 mg/kg to 2,250 mg/kg) (EPA, 1984q). Because of the positive female rat results, a cancer risk analysis has been conducted on picloram in this risk assessment under the assumption that picloram is carcinogenic.

Simazine Carcinogenicity

The limited chronic studies conducted on simazine do not indicate that simazine is carcinogenic. EPA has requested additional data to assess the possible carcinogenicity of simazine.

The study on the atrazine-simazine mixture (Fogard-S) described above is not considered substantive evidence of the carcinogenicity of either of the constituents. Attachment A presents the details of that study.

Tebuthiuron Carcinogenicity

Available evidence do not indicate that tebuthiuron is carcinogenic. No carcinogenic effects were observed in a chronic feeding study in which rats and mice were fed from 0 to 1,600 ppm tebuthiuron in their diets for 2 years (USDA, 1984).

Triclopyr Carcinogenicity

Available data do not indicate that triclopyr is carcinogenic. For both rat and mouse 2-year feeding studies (Dow Chemical Company, 1983b, in USDA, 1984) and a 228-day dog feeding study no oncogenic effects occurred in test animals exposed to triclopyr.

Cancer Potency

This subsection presents the results of the cancer potency analysis for each of the herbicides assumed to be carcinogenic in this risk assessment. (See Attachment A for details of this analysis.) The cancer potency value is used later in the risk analysis to determine the human cancer risk under specified assumptions about lifetime human exposure.

The cancer potency of a chemical is defined as the increase in likelihood of getting cancer from a unit increase in the dose of the chemical. This relationship is illustrated by the graph of Figure 3-2. The line specifies what the increase in cancer probability is for each unit increase in dose in mg/kg/day.

The cancer potency is derived from tumor data generated in laboratory animal studies. Note in Figure 3-2 that the dose levels used in the laboratory cancer studies are high but those liable to be experienced by humans through exposure in the environment are low. Note also that the line relating dose to cancer probability approximates a straight line in the low dose region.

Several aspects of this analysis make the cancer potency estimates very high (pessimistic). First, it is assumed that any dose, no matter how small, has some probability of causing cancer. This is the nonthreshold property, discussed previously, indicating that even a single, extremely small dose may be enough to trigger cancer. Amitrole, for example, has been shown to cause cancer in test animals only at relatively high doses. EPA recommends using a threshold approach to analyze amitrole's carcinogenicity, but this analysis uses the nonthreshold assumption for all seven herbicides.

Second, one of the principal areas of scientific controversy in cancer risk assessment is in extrapolating from the high doses used in animal studies to the far lower doses humans may get. Models other than the one-hit model, which assumes a straight line at low doses as illustrated in Figure 3-2, have been used for the extrapolation of cancer data to assess human risk. However, the one-hit model used in this analysis gives the

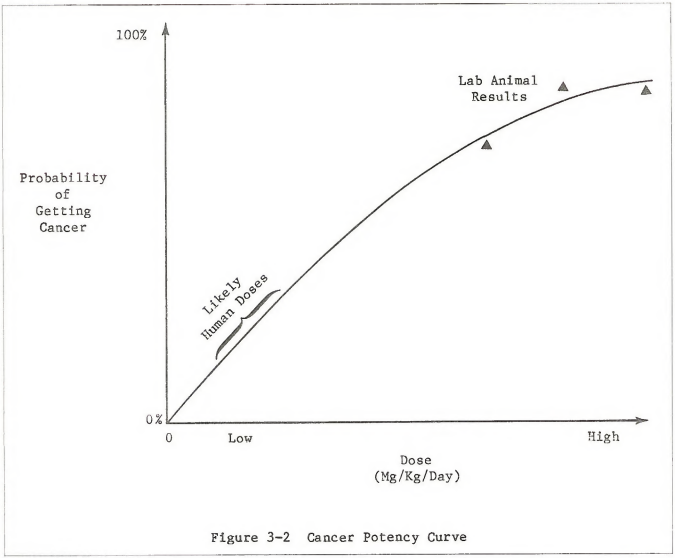


Figure 3-2 Cancer Potency Curve

highest estimate of cancer potency and, in turn, cancer risk at the low doses liable to be seen in exposed humans.

Third, the cancer potency used in the calculation of human risk in this analysis is not the expected potency value, but the upper limit value of the 95-percent statistical confidence interval. Using this upper limit value gives a potency that is approximately twice as high as the expected potency estimate. The details of the cancer potency derivation for all of the chemicals based on the one-hit model are given in Attachment C.

Amitrole Cancer Potency

Amitrole cancer potency was estimated using data from three studies:

1. A 2-year rat feeding study conducted by Hazleton Laboratories, Inc.
2. A study by Tsuda et al. (1976) in which rats were given 2,500 ppm in their drinking water.
3. A study by Food and Drug Research (1981, as cited in EPA, 1985a) in which rats alternately were fed food with and without amitrole.

The cancer potency for amitrole estimated from the Hazleton Labs rat study data was 0.15 per (mg/kg/day). The data of Tsuda et al. (1976) gave a potency of 0.011 per (mg/kg/day) for all invasive thyroid lesions and 0.00098 per (mg/kg/day) for papillary adenoma. The Food and Drug Research 1981 study (as cited in EPA 1985a) indicated a cancer potency for thyroid tumors of 0.61 (considering only the intermittently dosed groups). In this risk assessment, the highest of these potencies is used to estimate human cancer risk. The 95-percent upper confidence limit for the potency based on the Food and Drug Research data is 1.4 per (mg/kg/day).

Asulam Cancer Potency

Asulam cancer potency was based on the rate of tumor formation in thyroid cells in male rats in a 107-week feeding study (EPA, 1983). The cancer potency using the one-hit model is 0.02 per (mg/kg/day).

Bromacil Cancer Potency

Bromacil cancer potency was based on the rate of liver tumor formation in male mice in an 18-month feeding study. The cancer potency estimated from the multistage model is 0.0038 per (mg/kg/day) (EPA, 1985e).

2,4-D Cancer Potency

2,4-D cancer potency was calculated based on the rate of tumor formation in the female Osborne-Mendel rats studied by Hansen et al. (1971). This is the species and sex that have exhibited the highest increase in tumor formation after 2,4-D administration. All tumors were considered, although many of them were benign. As in the case of amitrole, the conservative one-hit model was used to represent the relationship between dose and rate of tumor formation. The 95-percent upper confidence limit of the cancer potency, calculated by Crump (1983) using the GLOBAL 82 computer program, was 0.00503 per (mg/kg/day).

2,4-DP Cancer Potency

A cancer study involving rats fed up to 200 mg/kg (EPA, 1982b) was used to derive 2,4-DP cancer potency. In this study, the highest dose group showed signs of general toxicity because they were fed more than the maximum tolerated dose of 2,4-DP. Many of the females at all dose levels had tumors but they did not show a dose-related response. Males showed a significant increase in the rate of incidence of malignant tumors, with a corresponding decrease in the rate of benign tumors. The tumors were primarily in the thyroid and pituitary glands.

The 95-percent upper confidence limit for the cancer potency of 2,4-DP was estimated from the male rat data as 0.059 per (mg/kg/day). Only malignant tumors were considered in this case, and the high dose group showing signs of general toxicity was not considered in order to give the highest cancer potency indicated by the data. The high dose group actually had fewer malignant tumors than the intermediate dose group.

Glyphosate Cancer Potency

Glyphosate cancer potency was based on the rate of kidney tumor formation in male mice in the feeding study reported in EPA (1985b).

The upper 95-percent limit of the cancer potency of glyphosate calculated from the kidney tumor data was 0.000034 per (mg/kg/day).

Picloram Cancer Potency

The Gulf Research Institute conducted a carcinogenic bioassay of picloram in rats and mice for the National Cancer Institute (1978). There was evidence that picloram affected the livers of male and female rats, and the study concluded that the findings were "suggestive of ability of the compound to induce benign tumors in livers of female Osborne-Mendel rats."

Using the one-hit model, a 95-percent upper confidence limit on picloram carcinogenicity has been calculated by Crump (1983) using the GLOBAL 82 computer program. His estimate is 0.00057 per (mg/kg/day). This is only about one-tenth as great as that for 2,4-D.

Section 4
Exposure Analysis

Introduction

This section presents the methods and results of the herbicide exposure analysis. The first subsection contains the basic background information used in defining the exposure analysis methods. The terminology of herbicide use and the potential human exposure from that use are discussed.

The second subsection presents the methods used to estimate herbicide doses to workers and members of the general public. The methods used for determining lifetime doses to workers and the public to evaluate the risk of cancer are described. The second subsection also discusses the populations at risk in the vegetation management programs.

The third subsection gives the results of the routine and accidental dose calculations for workers and the public for each herbicide and the results of the lifetime dose estimation.

Some Helpful Terms

This subsection defines some of the terms used in the discussion of the exposure analysis methods and explains the relationship between the doses estimated in the analysis and the doses that might actually occur in future herbicide treatment operations. Other terms may be found in the Glossary.

Herbicide Characteristics

Most herbicides are packaged and sold by the manufacturer in liquid form as a concentrate with a specified number of pounds of active ingredient, usually between 1 and 10, per gallon of concentrate and with inert ingredients forming the remaining portion. Many of the herbicides also are marketed in the form of wettable powder and granular formulations.

Before herbicides are applied, they are mixed with a carrier, usually water, according to the manufacturer's label instructions for the particular treatment purpose and the desired application rate in pounds of active ingredient per acre. The amount of concentrate that produces the desired amount of active ingredient per acre treated normally is mixed with 10 to 15 gallons of carrier for every acre to be treated in aerial applications and with 50 to 100 gallons of carrier for every acre to be treated in ground applications. Herbicide concentrate, stored in 30- to 55-gallon drums, is prepared for application and then is transferred to application equipment by a mixer-loader, who uses a batch truck that has separate storage tanks for the carrier and for the herbicide mixture.

Herbicide application equipment is designed to cover the target plants with a minimum of off-target spray movement, called drift. Spray equipment nozzles aredesigned to produce medium to large droplets because smaller droplets tend to remain airborne and may drift with air currents away from the target vegetation. Despite the effectiveness of the application equipment used, some small fraction of the droplets may break up into smaller droplets that the wind could blow offsite. Hand application techniques, such as injection and hack and squirt, do not use sprays; thus, these techniques do not produce herbicide drift (see description of hand application on page 2-3).

Exposure and Dose

Two primary conditions are necessary for a human to receive an herbicide dose that may result in a toxic effect. First, the herbicide must be present in the person's immediate environment so that it is available for intake. It must be in the air the person breathes, on the person's skin, or in the person's food or water. The amount of herbicide present in the person's immediate environment is the exposure level.

Second, the herbicide must get into the person's body by some route. If it is in the air, it may be inhaled into the air passages and lungs. If it is on the clothing or skin, it may penetrate the skin. The amount that moves into the body by any of these routes constitutes the dose.

Thus, although two people may be subjected to the same level of exposure—for example, two workers applying herbicide with backpack sprayers—one may get a much lower dose than the other by wearing protective clothing, using a respirator, or washing immediately after spraying. Exposure, then, is the amount of herbicide available to be taken in; dose is the amount that actually enters the body.

Potential Routes of Human Exposure

The potential routes of exposure to humans from herbicide treatment operations are illustrated in Figure 4-1 The routes of exposure considered in this risk assessment in estimating doses to workers and the public that might occur during routine operations or in the event of an accident are listed in Table 4-1 and are described below. Food items and drinking water sources that may lead to ingestion (dietary) exposures are listed in Table 4-2.

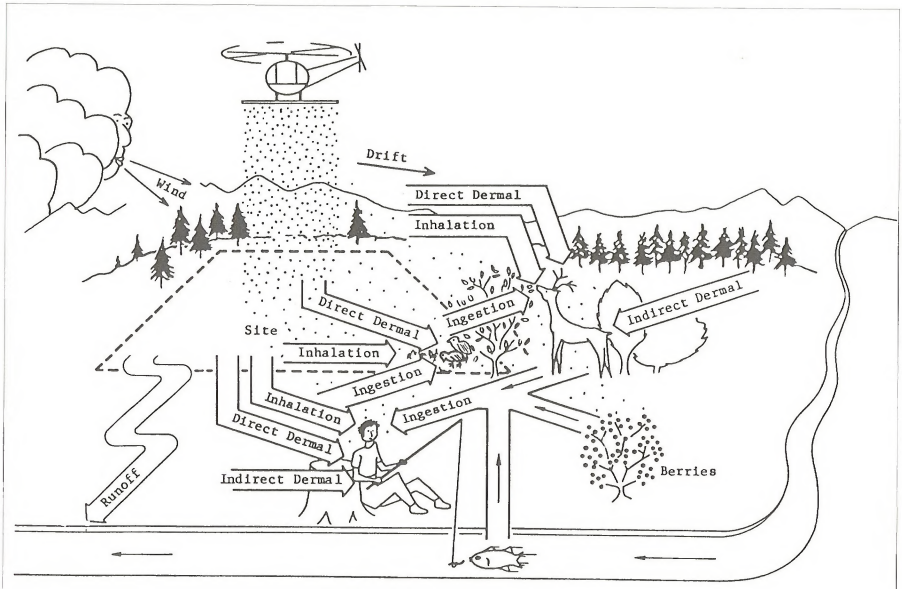


Figure 4-1 Routes of Exposure to Herbicides in Spraying Operations

Table 4-1
Routes of Exposure Considered in This Risk Assessment

	Doses from Direct Exposure	Doses from Indirect Exposure
Routine		
Workers	Total dose (based on field studies)	Dermal dose from reentry to treated area based on field data
General Public	Dermal dose [a] from drift (based on modeling)	Dermal dose from vegetation contact in drift area and from consuming food with residues[b]
Accidental		
Spraying	Dermal dose[a] to member of public directly sprayed	Worker vegetation contact dose from reentry to treated area immediately after spraying. Dose to member of public who walks through treated area and who eats directly sprayed food items[b]
Spills	Worker dermal dose from spill of concentrate or mixture on skin	Dose to member of public from drinking water contaminated by an herbicide spill

[a]Inhalation is negligible based on field study data.
[b]See Table 4-2 for diet items used in dose estimates.

Table 4-2
Dietary Exposures Estimated in This Risk Analysis

Scenario	Water	Food Items
Routine		
Realistic	Drift onto pond	Garden vegetables offsite Berries offsite Meat from a deer feeding offsite Meat from a game bird feeding offsite Fish caught in a pond receiving drift
Worst Case	Drift onto pond that is closer than realistic	Food items same as in realistic but closer to treatment unit
Accidental		
Spraying	Pond directly sprayed	Garden vegetables onsite Berries onsite Deer feeding in treated area Fish caught in pond directly sprayed Game bird directly sprayed
Spills	100- or 1,000-gal spill of mix in drinking water supply	

Potential Human Exposures from Routine Operations

The greatest doses to humans in routine herbicide applications are to workers who may be exposed while: (1) mixing and loading herbicide into application equipment, (2) applying herbicide to vegetation using ground-based equipment, or (3) supervising or monitoring aerial or groundbased herbicide applications. Use of protective clothing and equipment and adherence to proper cleanup procedures and label precautions in general lead to significant reductions in the doses of workers.

The single most important source of exposure to persons who do not handle the herbicide containers or spray equipment in routine operations is from the drift off target of airborne herbicide spray droplets. Spraying only under favorable weather conditions and the use of spray equipment that limits the number of smaller spray droplets reduces the amount and extent of drift.

During routine operations, workers may be dermally exposed to an herbicide if the herbicide concentrate, mixture, or drifting spray droplets contact the skin or if the herbicide is brushed off of sprayed vegetation. Inhalation exposure may result from breathing without protective devices in the area of the drifting spray droplets or where there are vapors from a volatile herbicide. However, a variety of studies have shown that inhalation exposure is very small compared with dermal exposure. In this analysis, inhalation doses have not been estimated separately for workers; they are included with dermal doses in the estimated total worker doses based on herbicide levels in the urine of workers in field experiments.

Members of the general public who are within the area of drift of the smaller spray droplets may also receive dermal and inhalation exposure, but their exposures are relatively low compared to the exposures of workers directly involved in the spraying operations. Field studies of workers have consistently shown that inhalation exposure represents only a small part of the total exposure, so doses to the general public in this analysis have been calculated only for dermal and dietary routes (see description of worker studies later in this section).

Herbicide may be ingested by members of the general public from food containing herbicide residues. Food items such as garden vegetables, wild berries, or game animals may have received some level of herbicide from spray drift. Game animals may have fed on plants from the drift area. Ingestion exposure could also result from drinking water that has received herbicide drift or from eating fish from a body of water that has received herbicide drift.

Potential Human Exposures from Accidents

In the event of an accident, workers and members of the public may be exposed to much greater amounts of herbicide than they would under normal circumstances. Workers who spill the concentrate or some of the prepared spray mixture on their skin during mixing, loading, or spraying operations or who are doused when a transfer hose breaks would be dermally exposed. Workers or members of the public who are accidentally sprayed with herbicide because they are beneath a spray aircraft or are too close to a truck or backpack applicator would receive a dermal dose.

The dermal dose would depend on the concentration of herbicide in the spray mix, the area of the sprayed person's exposed skin, the extent to which the person's clothing absorbed herbicide (some clothing is water repellent, but other material would permit penetration of the herbicide to the skin), and the time that elapses before the person can wash. Indirect dermal (reentry) exposure may occur if workers or members of the public brush up against wet vegetation in the sprayed area.

Members of the public may accidentally be exposed to the herbicide by eating food or drinking water that has been directly sprayed. For example, members of the public may eat berries that have been directly sprayed, or they may eat meat from deer that have recently foraged on a sprayed site. Exposure to even higher levels of herbicide is possible if a container of herbicide concentrate were to break open and spill into a drinking water supply.

Exposure Analysis Methods

Application Scenarios

To make reasonable estimates of the possible herbicide doses to workers and the public, a number of application scenarios are used that represent an array of likely treatment situations. Routine application scenarios were designed to provide a range of human dose estimates, from realistic to worst case, for normal operating conditions. Accidental-worst case scenarios—direct application, spills on the skin, and large spills into bodies of water—are used to estimate the highest doses that could ever be reasonably expected to occur. All but the lowest doses from all vegetation management projects conducted in the Pacific Northwest should fall within the range of doses predicted in these scenarios.

The scenarios specify those characteristics of each kind of herbicide application operation that determine human doses. For example, for workers involved in backpack operations, the number of work hours and the herbicide application rate are used to determine their doses. For aerial applications, the number and size of the sites treated in a day's operation are used. To calculate doses to nearby residents who may eat a garden vegetable containing herbicide residue, it was necessary to estimate how much residue was on the vegetable and to specify how much of the vegetable was eaten.

The application scenarios were not intended to show what necessarily will happen as a result of a given treatment operation, but what could happen if all of the conditions specified in the scenario were met in the actual operations. For example, worker doses are based on actual dose levels found in field exposure studies in which no protective clothing or equipment was worn. If workers were to wear protective clothing and equipment during actual operations, their doses could be significantly lower than those estimated here. However, despite all precautions, workers present during treatment operations will be exposed to some extent.

Additional factors must be recognized when evaluating the likelihood of a member of the public receiving an herbicide dose. A forest user would receive a dose only in the immediate vicinity of the treatment area and only at the time of the herbicide application. However, because of the limited area of forest being treated and the public's restricted access and use, the possibility of this occurrence is slight. Likewise, a nearby resident would receive a dose as high as the one estimated in this analysis from eating garden vegetables with herbicide residue only if all of the following conditions were met:

1. The resident's garden was close enough to a particular treatment area to receive some level of herbicide drift.

2. The weather conditions on the day of treatment were such that the herbicide happened to drift offsite in the direction of the garden.

3. The resident ate the vegetable immediately after the herbicide residue landed on it.

A combination of factors makes the possibility of the resident receiving such a dose highly unlikely. First, most treatment areas are located considerably further from any residence than the distance assumed in this analysis—600 feet. Second, mitigation measures described in Section 2 reduce the likelihood of drift onto a garden, even if one happened to be nearby. Third, there is only a small possibility the resident would immediately pick and eat a garden vegetable that had herbicide residue from that operation.

Workers Doses from Routine Operations

Herbicide doses to workers involved in routine operations were estimated using eight herbicide application scenarios: four routine-realistic and four routine-worst case scenarios. For each application scenario, worker categories were chosen to represent the normal range of work activities in terms of potential herbicide exposure. Other categories of workers may experience less exposure, but no category of workers in the field is expected to experience greater exposure than the types of workers considered in this analysis.

Doses to members of the public as a result of routine operations were estimated using three of the routine-realistic and three of the routine-worst case scenarios used to derive the worker doses. Again, other categories of the public may receive less exposure, but no one should receive more under normal operating conditions.

Worker Categories and Calculations in Routine Operations

Worker dose levels were extrapolated directly from worker doses determined by urine analysis in field studies of actual herbicide treatment operations. Because the field studies showed what dose levels are experienced in actual operations, they were considered the most appropriate basis for estimating the doses of Forest Service Region 6 and BLM herbicide applicators involved in the same or similar vegetation management practices. Those studies are discussed in the next subsection.

Dose estimates were scaled to the anticipated work hours and herbicide application rates specified in each of eight application scenarios.

Routine-realistic. To estimate routine-realistic worker doses, average dose levels found by urine analysis in field studies of workers exposed in spraying the herbicides amitrole, 2,4-D, 2,4-DP, dicamba, and picloram using the same application method were used. Nominal dose levels in mg/kg/hr for a 1-lb/acre application rate for workers in each category (see below) were derived from these average dose levels by dividing by the field study hours worked and application rate. Realistic dose levels for each of the five herbicides studied in the field were estimated by multiplying the nominal doses by typically used application rate of the particular herbicide and the normal number of hours worked per day in that type of operation.

Application rates for the routine-realistic dose scenarios are listed in Table 4-3. Where a field study has not been done using one of the five herbicides in a particular application method, and for the 11 herbicides not studied in the field, the exposures were estimated by extrapolating from the dose levels found in the 2,4-D studies.

The worker categories and scenarios used for estimating the routine-realistic worker doses included the following:

1. Doses to pilots, mixer-loaders, supervisors, and observers in a helicopter broadcast treatment of four 40-acre silviculture sites

2. Doses to applicators, mixer-loaders, and applicator/mixer-loaders in truck broadcast spraying of 12 acres (33 feet wide by 3 miles long) of roadway right-of-way

3. Backpack applicator doses in backpack spraying of a 6-acre facilities maintenance site by two applicators for 6 hours

4. Doses to applicators using hack-and-squirt and injection-bar methods in hand treatment of 3 acres by two applicators for 6 hours

Again, for the herbicides that were not studied in the field, worker doses for each worker category were estimated by extrapolating from the average dose levels found in field studies of workers exposed to 2,4-D using the same application method. The following steps were involved:

1. The total number of acres treated was estimated by multiplying the treatment rate in acres per hour found in the field studies by a specified number of treatment hours.

2. The acreage figure was used to determine the number of pounds of active ingredient used in the scenario by multiplying by the herbicide's typical application rate (listed in Table 4-3).

3. The herbicide-specific dose was determined by multiplying the pounds of herbicide applied by the dose of 2,4-D per pound of 2,4-D applied for that worker category in the field studies and then adjusting for the herbicide's dermal penetration rate. The dermal penetration rates used in the analysis were 6 percent for 2,4-D (Feldman and Maibach, 1974), 6.4 percent for 2,4-DP, 0.48 percent for picloram (Lavy et al., 1984), 5 percent for dicamba (Draper and Street, 1982), 0.1 percent for amitrole, and 10 percent for the other 11 herbicides (USDA, 1984).

For the herbicides that had been used in field studies of worker exposure (amitrole, 2,4-DP, dicamba, and picloram), the same method was used, but average doses were derived from the appropriate field study. The field studies on all five herbicides are listed in Table 4-4 and are described below.

Routine-Worst Case. Routine-worst case worker doses were estimated for the same worker categories used in the routine-realistic scenarios. However, the site size, application rate, equipment

Table 4-3
Application Rates Used for
Routine-Realistic and Routine-Worst Case Scenarios
(lb active ingredient/acre)

	Aerial		Backpack		Right-of-Way	
	Realistic	Worst Case	Realistic	Worst Case	Realistic	Worst Case
Amitrole	2.00	4.00	2.00	5.00	2.00	8.00
Asulam	2.40	3.34	1.20	3.34	2.40	5.00
Atrazine	3.75	4.00	3.00	4.00	3.00	8.50
Bromacil	0.00	0.00	4.00	10.00	4.00	10.00
2,4-D	2.50	4.00	2.00	4.00	2.50	4.10
2,4-DP	2.00	2.50	2.00	4.30	2.50	5.00
Dalapon	4.00	10.00	4.00	12.00	4.00	10.00
Dicamba	1.00	4.00	0.50	4.00	1.00	3.60
Diuron	0.00	0.00	4.00	6.00	4.00	16.00
Fosamine	3.00	12.00	3.00	11.50	4.00	10.70
Glyphosate	2.00	5.00	1.50	5.00	2.00	5.00
Hexazinone	2.50	3.00	1.12	3.00	2.50	6.00
Picloram	1.00	5.00	1.00	4.00	1.00	2.00
Simazine	4.00	5.00	2.00	4.60	2.00	4.60
Tebuthiuron	1.00	6.00	1.50	6.00	2.20	4.60
Triclopyr	2.00	8.00	2.00	8.00	2.00	8.00

Table 4-4
Worker Studies Used for Herbicide Exposure Estimation

Application Method	Herbicide Studies				
	2,4-D	2,4-DP	Picloram	Dicamba	Amitrole
Aerial	Lavy et al., 1982				EPA Off. of Pest. Programs
Truck	Nash et al., 1982	Kolmodin-Hedman et al., 1983 Libich et al., 1984	Libich et al., 1984	Draper et al., 1982	Dynamic Corp. EPA Off. of Pest. Programs
Backpack	Lavy et al., 1984		Libich et al, 1984		EPA Off. of Pest. Programs
Hand Application	Lavy et al., 1984		Lavy et al., 1984		EPA Off. of Pest. Programs

type, meteorological conditions, and duration of exposure were set to those that would lead to the highest levels of exposure in herbicide treatment operations in the Region. Herbicide-specific dose levels in the routine-worst case scenarios were again derived from the worker field studies and weighted for application rate and hours exposed, but here the 95 percent upper confidence level of the field study doses was used for extrapolating to the nominal dose in mg/kg/hr for a 1-lb/acre application rate. Application rates used in the routine-worst case scenarios are listed in Table 4-3.

The worker categories and scenarios used for estimating routine-worst case worker doses included the following:

1. Doses to pilots, mixer-loaders, supervisors, and observers in fixed-wing broadcast spraying of a 400-acre site for range improvement

2. Doses to applicators, mixer-loaders, and applicator/mixer-loaders in truck broadcast spraying of 40 acres of transmission line right-of-way

3. Backpack applicator doses in backpack spraying of a 60-acre conifer release site by 14 applicators for 9 hours

4. Doses to applicators using hack-and-squirt and injection-bar methods in hand treatment of 9 acres by four applicators for 9 hours

Field Studies of Worker Exposure

Field studies of the exposures and resultant doses of workers using a variety of application equipment have been conducted on 5 of the 16 herbicides evaluated in this risk assessment: amitrole, 2,4-D, 2,4-DP, dicamba, and picloram. The worker exposure studies used for dose estimation for the five studied herbicides in this analysis are listed in Table 4-4. Doses for each worker category found in the studies are listed in Table 4-5.

2,4-D Worker Exposure Studies. Kolmodin-Hedman and Erne (1980) studied the occupational exposure to phenoxy acids 2,4-D and 2,4,5-T of four men spraying 2-percent emulsion in kerosene from tractor-driven equipment with special protective clothing and procedures used. Draper and Street (1982) investigated worker exposure to 2,4-D, dicamba, and a dicamba isomer during application to a 42-acre pasture in Utah. Franklin et al. (1982) estimated worker exposure in pasture brush clearing operations in Saskatchewan using techniques similar to Lavy and co-workers, but operations were conducted on 3 of 4 successive days.

Lavy et al. (1982) monitored three helicopter spray crews for worker exposure to 2,4-D, using portable air filters, denim patches, and urine analysis on two separate spraying dates; the first observing normal precautions, the second using special protective clothing and procedures. Nash et al. (1982) monitored exposure of workers to 2,4-D during aerial spraying in Washington and ground spraying in North Dakota under normal spray conditions (i.e., without special precautions). Taskar et al. (1982) examined 2,4-D exposure of 11 volunteers during application of the herbicide to small 1-acre lots in New Jersey.

Kolmodin-Hedman et al. (1983) monitored air concentration and urine levels of 24 farmers and 9 professional sprayers in Sweden who used varying degrees of protective clothing. Linnainmaa (1983) investigated the induction of primary DNA damage

Table 4-5
Doses of 2,4-D Measured in Exposure Studies for Each Worker Category

Investigator	Application Type and Rate	Equipment Used	Worker Category	Number of Workers	Method of Analysis	Doses Average	Doses Range
Lavy et al., 1982	Aerial, 2.2 Kg a.i./ha	Helicopter	Flagman	2		--	0.00119-0.00177 mg/kg/day
			Pilot	3	Denim	0.00057 mg/kg	n.d.-0.0010 mg/kg
			Mechanic	3	Patches	0.0233	0.0233-0.0617
			Batchman	3		0.0448	0.0233-0.0911
			Supervisor	3		0.0167	n.d.-0.0005
			Observer	6		8×10^{-5}	n.d.-0.0005
			Pilot	3	Urine	0.00248 mg/kg	0.00179-0.0557 mg/kg
			Mechanic	3		0.00068	0.00044-0.0136
			Batchman	3		0.00245	0.00215-0.0377
			Supervisor	3		0.00029	n.d.-0.0069
			Observer	6		0.00006	n.d.-0.0013
	Aerial	Helicopter, Special Precautions: Protective Coveralls, Gloves, Boots, Hats, Goggles	Pilot	3	Denim	3.3×10^{-5} mg/kg	n.d.-0.0001 mg/kg
			Mechanic	3	Patches	0.00577	0.0005-0.0162
			Batchman	3		0.01065	0.00016-0.0216
			Supervisor	3		0.0009	n.d.-0.0027
			Observer	6		0.0014	n.d.-0.0045
			Pilot	3	Urine	0.00854 mg/kg	n.d.-0.0237 mg/kg
			Mechanic	3		0.00301	n.d.-0.00516
			Batchman	3		0.01401	0.00053-0.0219
			Supervisor	3		0.00013	n.d.-0.00038
			Observer	6		9 x 10-5	n.d.-0.00056
Nash et al., 1982	Aerial, 585 kg a.i. applied in 20 hrs.	4 Thrush Commanders 4 Grumman Ag-Cats 4 Pipers 1 Snow 1 Cessna	Mixer-loader	6	Urine	0.0199 mg/kg	0.0008-0.0545 mg/kg
			Mixer/ loader-pilot	1		0.0180	
	360 kg a.i. applied in 14 hrs.		Pilot	10		0.006 mg/kg	0.0013-0.0202 mg/kg
	Ground 34 kg a.i. applied in 3.5 hrs.	Sprayers: 4 Pull-type 21 Self-propelled 10 cab	Sprayers	9	Urine	0.012 mg/kg	n.d.-0.0760 mg/kg
	18 kg a.i. applies in 2.4 hrs.	16 no cab	Mixer-loader	7		0.0068	0.00165-0.0164
	38 kg a.i. applied in 7.9 hrs.		Mixer/ loader-sprayer	8		0.020	0.0037-0.0442

Table 4-5 cont.
Doses of 2,4-D Measured in Exposure Studies for Each Worker Category

Investigator	Application Type and Rate	Equipment Used	Worker Category	Number of Workers	Method of Analysis	Doses Average	Doses Range
Lavy et al., 1984 (As cited in USDA, 1984)	Ground, Weedone 170 (50% 2,4-D, 50% 2,4-DP) 1 gal. herbicide/24 gal. water	Backpack	Operator	20	Urine	0.01752 mg/kg/day	n.d.-0.0903 mg/kg/day
	Tordon 101-R (80% 2,4-D, 20% Picloram)	Injection bar	Operator	20	Urine	0.0019	n.d.-0.0095
	Tordon 101-R	Hypohatchet	Operator	20	Urine	0.01696	n.d.-0.0886
	Tordon 101-R	Hack and squirt	Operator	20	Urine	0.00576	n.d.-0.0451
Note: protective coveralls, gloves, boots, hats, goggles used	Weedon 170	Backpack	Operator	20	Urine	0.0196 mg/kg/day	0.0004-0.1175 mg/kg/day
	Tordon 101-R	Injection bar	Operator	20		0.00086	n.d.-0.0035
	Tordon 101-R	Hypohatchet	Operator	20		0.0079	n.d.-0.0439
	Tordon 101-R	Hack and squirt	Operator	20		0.00244	n.d.-0.0148

(sister chromatid exchanges) in cells of the lymphatic system (lymphocytes) of workers spraying 2,4-D, MCPA, or their mixtures. Nigg and Stamper (1983) investigated 2,4-D exposure to four workers who used airboats for mosquito and aquatic weed control in Florida. Lavy et al., (1984) investigated herbicide exposure to four spraying crews of 20 workers each, monitoring urine levels over two 5-day periods.

2,4-DP Worker Exposure Studies. Kolmodin-Hedman et al. (1983) investigated 2,4-DP exposure to agricultural workers under the same conditions mentioned previously in the case of 2,4-D exposure. Lavy et al. (1984) measured worker exposure to 2,4-DP in the study described previously concerning 2,4-D.

Picloram Worker Exposure Studies. Lavy et al. (1984) investigated worker exposure to picloram in the study described previously for 2,4-D.

Dicamba Worker Exposure Studies. Draper and Street (1982), in the study previously described for 2,4-D, measured dicamba exposure to truck crews spraying a mixture of dicamba and 2,4-D.

Amitrole Worker Exposure Studies. The U.S. EPA Office of Pesticide Programs Report (1983a) estimated potential dermal and inhalation exposure of workers applying amitrole. A second EPA report (1983b), prepared by Dynamac Corp. for the Union Carbide Agricultural Products Co., included exposure assessment of workers applying amitrole. Investigators in the worker exposure studies used urine analyses to determine the doses workers received under actual field conditions. This was possible because the herbicides studied, particularly 2,4-D, were known to be virtually completely eliminated from the body in the urine within 1 week after receiving a dose. At the same time, the investigators tried to estimate the dermal and inhalation exposures that led to the worker's doses by attaching absorbent patches to the worker's clothing to estimate dermal exposure and positioning portable air samplers near their breathing zone to estimate inhalation exposure.

Study results showed poor correlation between exposure estimates based on the patch and air sampling data and dose estimates based on urine analysis. Because the urine analysis data gave the most consistent results and were based on the amount of herbicide that actually entered the body rather than on the amount in the worker's immediate environment, the investigators believed the urine-derived dose estimates were the best estimates of actual worker doses received.

Why the Worker Dose Estimates Are Higher than Would Occur in Actual Operations

As described above, this risk assessment estimates two separate dose levels for each category of worker in routine operations, a realistic dose and a worst case dose. The realistic dose is an estimate of the average dose a worker should receive on a typical day during normal treatment operations. The realistic dose is based on combining average nominal doses from field studies with scenario conditions that are typical for Forest Service and BLM operations in the Pacific Northwest.

However, the realistic dose estimates are higher than those that would occur in actual operations for two reasons. First, the doses are based on field study doses of applicators who wore no special protective clothing or devices. Many of the field studies measured doses to workers both with and without protective gear, and the applicators in many of the proposed Forest Service and BLM operations will wear protective gear, but the lower doses of protected workers were not used in extrapolating to the doses estimated in this analysis. Second, during the field exposure studies, many of the less severe types of accidents occurred that could be termed operational errors. For example, pilots handled the transfer hoses and helped with the mixing and loading operations and, in one instance when a pump broke down, transferred spray mix by bucket to the spray tank. In both of these cases, these individuals received higher doses during that day's work than they would have otherwise. Nevertheless, their doses were used in deriving the average worker doses for that field study.

The worst case estimates of worker doses in routine operations are extremely high for two reasons. First, the nominal dose levels from the field studies used for extrapolation are not the average doses seen but the dose at the upper limit of the 95-percent confidence interval as illustrated in Figure 4-2. This means that there is only 1 chance in 40 that a worker in the same field operation under the same conditions of terrain, weather, and equipment should receive a dose higher than the specified dose. Second, when this upper limit dose is combined with the assumptions of largest site size and highest application rate for dose extrapolation, extremely high doses are estimated that are unlikely to occur under true operational conditions. The probability of all of these events occurring at the same time, as discussed in Chapter 5, is less than 1 in 10,000. No workers are likely to receive a higher dose under routine operational conditions unless they are involved in one of the accidents described in the subsection on page 4-27.

Because of the large number of actual field measurements, these extreme or routine-worst case estimates of doses to workers also take into account normal operational errors such as:

1. Errors of measurement during manufacturing and formulation
2. Errors of measurement during field mixing
3. Excessive swath overlap during application

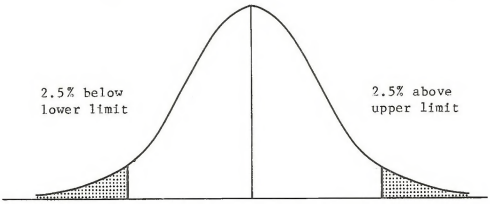


Figure 4-2 Distribution of Field Study Worker Doses

Public Exposures and Doses from Routine Operations

Public Exposure Categories and Calculations for Doses from Routine Operations

Herbicide doses to the public potentially exposed to routine herbicide applications were estimated using six application scenarios. They are the same as the worker scenarios except hack-and-squirt and injection-bar methods were not included. The hand application scenario was excluded because no drift is involved and the chance that any other type of public contact with the herbicides might occur in these operations is negligible. In the remaining six scenarios, inhalation exposure was not estimated because none of the herbicides in question is a specific lung toxicant and because the worker field studies have consistently shown inhalation exposure to be an insignificant fraction of the total herbicide dose received (USDA, 1984). Only dermal and dietary routes of exposure were considered in this analysis.

The scenarios used for deriving routine-realistic public exposures and doses were:

1. Helicopter spraying of a single 40-acre silviculture site

2. Truck spraying of a 12-acre roadway right-of-way

3. Backpack spraying of a 6-acre facilities maintenance site by two applicators for 6 hours

The scenarios used for deriving routine-worst case public exposures and doses were:

1. Fixed-wing spraying of a 400-acre site for range improvement

2. Truck spraying of 40 acres of transmission line right-of-way

3. Backpack spraying of a 60-acre conifer release site by 14 applicators for 9 hours

Single Routes of Exposure. The following categories of exposure were estimated for each scenario: doses due to drift, vegetation contact by a hiker or berrypicker, and the dietary exposures shown in Table 4-2.

Dermal dose estimates were derived from the estimated dermal exposure levels by assuming that 2 square feet of a person's skin was exposed and by adjusting for the dermal penetration rate of each herbicide. Ingestion dose estimates were made for the five specific food items and drinking water that receive herbicide residues shown in Table 4-2.

Multiple Routes of Exposure. In addition to estimating doses to the public from routine operations through the specific exposure routes described above, five categories of persons were assumed to receive doses simultaneously through a number of exposure routes: (1) a hiker, (2) a person who picks berries, (3) a hunter, (4) a fisherman, and (5) a nearby resident. Each of these persons was assumed to receive an herbicide dose that is the sum of the doses from several routes of exposure as shown in Table 4-6.

It is extremely unlikely that a member of the public will receive simultaneous herbicide doses through more than two of the exposure routes described above. However, to ensure that no possible dose was omitted from the analysis, it was assumed that the hiker receives dermal exposure from drift as well as vegetation contact exposure from brushing against offsite plants that have received drift. The hiker also drinks water that has received herbicide drift. The berrypicker receives the same dermal and drinking water exposure from drift as the hiker, but the berrypicker is exposed to a higher level of vegetation contact exposure from brushing against plants that have received drift because of continuous contact with the berry plants. The berrypicker also receives exposure from feeding on berries that have herbicide residues from drift.

The hunter is assumed to get the same dermal exposure, vegetation contact, and drinking water exposure as the hiker. In addition, the hunter is assumed to kill and eat a deer and a game bird that have been exposed and have fed on items in the area of herbicide drift. The fisherman receives the same doses as the hunter, except the fisherman eats fish taken from a pond that has received drift rather than eating a deer and a game bird. The nearby resident receives the same dermal exposure, vegetation contact, and drinking water exposure as the hunter, but the resident eats vegetables from a garden that has received herbicide drift.

Public Dose Estimation

Because no field studies existed on actual doses to the public comparable to those used for estimating worker doses, it was necessary to estimate public doses by modeling the transport and fate of the applied herbicides. Details of the transport and fate modeling are in the next subsection.

Table 4-6
Multiple Routes of Exposure for Example People

Example People	Direct Dermal	Reentry Hiker	Reentry Berrypicker	Drinking Water	Eating				
					Berries	Vegetables	Deer	Bird	Fish
Hiker	X	X		X					
Berrypicker	X		X	X	X				
Hunter	X	X		X			X	X	
Fisherman	X	X		X					X
Nearby Resident	X	X		X		X			

X = Member of the public exposed by this route.

Surface herbicide residue levels were estimated using data from field studies of the drift and surface deposition of herbicides in aerial and ground-based spray operations. These empirical studies were used to calculate how much was deposited on people's skin and how much was deposited on food and vegetation, and in bodies of water.

The exposure models required input of expected distances to various sources of human exposure. Figures 4-3 through 4-8 illustrate the distances to sources of public exposure in each scenario. The distances were derived from an examination of currently used mitigation measures.

Why the Public Dose Estimates Are Higher than Would Occur from Actual Operations

The doses estimated for members of the general public are overestimates for a number of reasons. First, downwind concentrations on surfaces used to compute dermal exposure were those found on flat mylar deposition sheets. The smaller spray particles in offsite drift tend to move around rather than impact on curved surfaces and therefore would have less of a tendency to adhere to a human's body. Second, no degradation of the herbicide is assumed to occur nor is the herbicide assumed to bind with any material, such as vegetation, so as to become biologically unavailable to humans. This would be an important factor in diminishing doses that may occur from any activity involving contact with treated vegetation.

The routine-worst case dose levels to the public can be considered the highest possible doses for routine spray operations because the doses are calculated in scenarios that combine many unlikely factors and events, including largest site size, highest application rate, least favorable weather conditions, and spray equipment most susceptible to offsite drift. No member of the public should get a dose that is any higher than the doses estimated in the routine-worst case scenarios except in the case of an accident.

Modeling Public Exposures and Doses

The following subsection presents a detailed discussion of the transport and fate modeling used in estimating herbicide doses to the public. Various sources for assumptions and methods of calculation were consulted (Dost, 1983; Crump, 1983; Simmons, 1983; USDA, 1984).

Spray Drift

The potential for herbicide sprays to drift onto adjacent lands or into nearby bodies of water was assessed based entirely on the results of empirical studies reported in the scientific literature. The analysis considered deposition on surfaces including exposed skin, water, game animals, and various classes of plants that may contribute directly or indirectly to the human diet.

Specific field studies were chosen to best represent the equipment and conditions appropriate for each scenario. Unfavorable conditions were chosen to show the degree of drift that could occur under the routine-worst case scenarios. Drift estimates for sprays applied in large range improvement projects were made based on the drift of 2,4-D from a fixed-wing aircraft (Miller, 1980). This test was conducted when winds averaged 9.5 mph. Mitigation measures specify no spraying if winds exceed 5 mph. Drift estimates for sprays applied in silvicultural projects were made based on drift of a dye tracer solution sprayed over a coniferous seed orchard by helicopter (Barry et al., 1983). The winds ranged from 4.5 to 9 mph. Drift of sprays applied by ground equipment was estimated based on a field test reported in Yates et al. (1978). In this test, glyphosate was sprayed by a ground sprayer when winds were 8.5 mph.

To facilitate use of the data from the various published field tests discussed above, a computer program was written to show how residues accumulate from multiple swaths (the long, narrow pattern of herbicide laid down by a broadcast

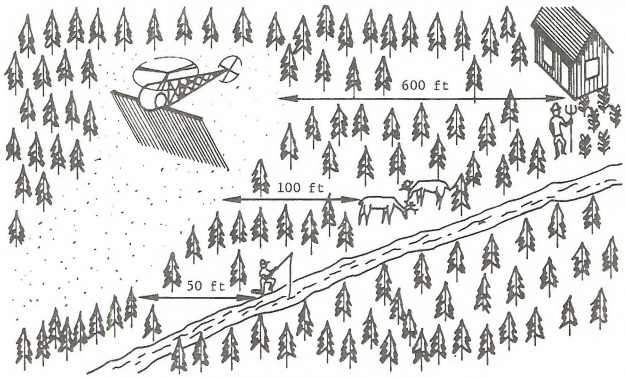


Figure 4-3 Routine-Realistic Aerial Scenario:
Helicopter Spraying of a 40-Acre Silviculture Site

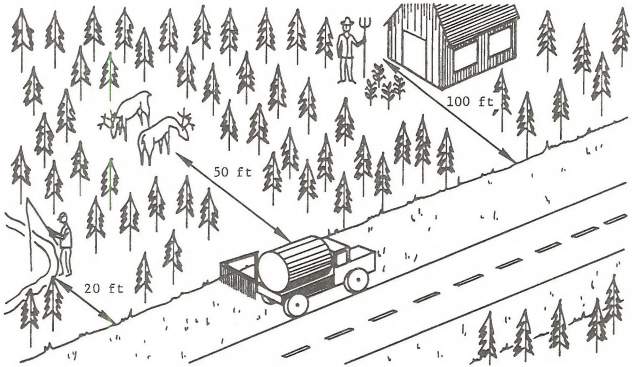


Figure 4-4 Routine-Realistic Right-of-Way Scenario:
Truck Spraying of a 4-Acre Roadway Right-of-Way

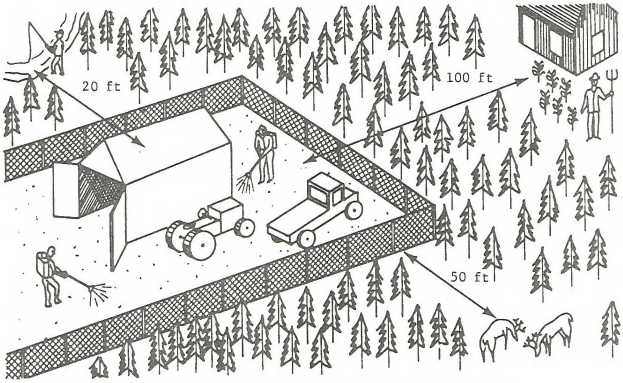


Figure 4-5 Routine-Realistic Backpack Scenario:
Treatment of a 6-Acre Facilities Maintenance Site

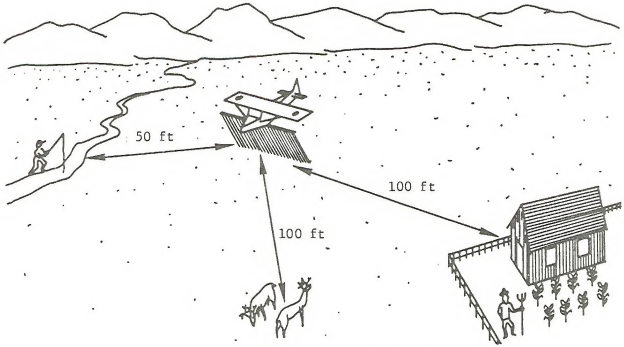


Figure 4-6 Routine-Worst Case Aerial Scenario
Fixed Wing Spraying of a 400-Acre Range Improvement Site

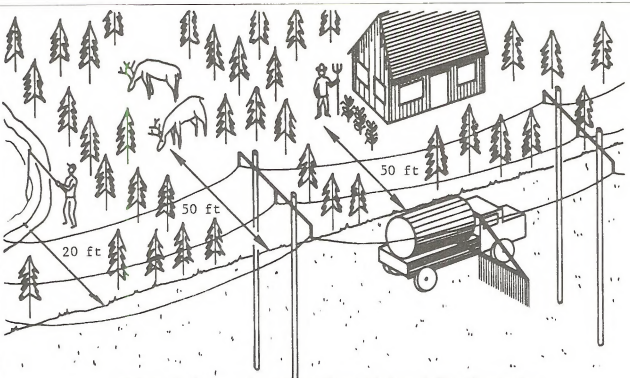


Figure 4-7 Routine-Worst Case Right-of-Way Scenario: Truck Spraying of 40 Acres of Transmission Line Right-of-Way

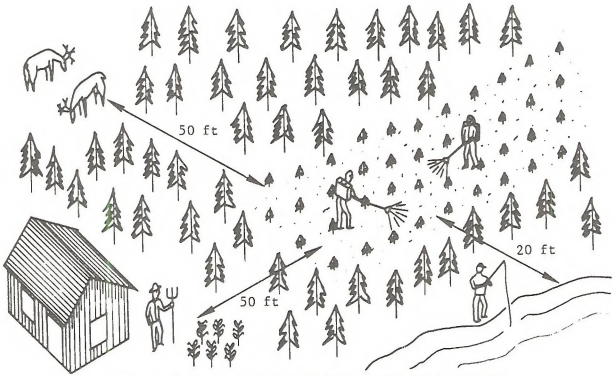


Figure 4-8 Routine-Worst Case Backpack Scenario: Treatment of a 60-Acre Conifer Release Site

sprayer such as an aircraft) and to correct for various application rates and swath widths. The program was then run to calculate deposition at selected representative distances for a nominal application rate of 1 pound per acre. The results are given in Table 4-7 for each of the six broadcast spray scenarios. The drift calculated for water bodies is intended to represent deposition at the edge of a minimum buffer strip (50 feet for aerial spraying and 20 feet for ground spraying).

Residues on Plants

Herbicide residues on plants on treated sites were estimated based on factors reported by Hoerger and Kenaga (1972). These factors were derived from a large number of studies, and they allow prediction of residues in parts per million (ppm) based on the application rate in pounds per acre. These residue estimates were calculated assuming no herbicide degradation, so they apply to conditions immediately after application. Following Hoerger and Kenaga (1972) the plants were classified into broad groups based on vegetative yield, surface-to-mass ratio, and plant interception factors. The residues estimated for each type of plant are intended to represent realistic yet relatively high estimates.

Offsite plant residues were calculated first for grasses based on the spray drift data discussed in the previous section and by using a regression equation given in Yates et al. (1978) to relate spray deposition on young wheat plants to that on sampling devices. The deposition was then estimated for other plant groups including berries and leafy vegetables by using the same relative factors given by Hoerger and Kenaga (1972), assuming that deposition on young wheat was approximately the same as deposition on range grass.

Table 4-7
Drift in mg/ft² Based on 1 lb/Acre for Routine Scenarios

Scenario	Realistic	Worst Case
Aerial Scenario		
To Public and Crops	0.0020	1.0595
To Berries and Animals	0.1571	1.0595
To Water	0.6682	2.2491
Right-of-Way Scenario		
To Public and Crops	0.0043	0.0150
To Berries and Animals	0.0090	0.0150
To Water	0.0264	0.0353
Backpack Scenario		
To Public and Crops	0.0222	0.0428
To Berries and Animals	0.0341	0.0428
To Water	0.0588	0.0678

Herbicide doses to individuals were calculated assuming that they eat 400 grams (0.9 pounds) of contaminated berries or peas.

Residues in Water

Residues in water were calculated assuming that the water is only 6 inches deep, and that the herbicide spray drifts directly downwind to the water body over a minimum buffer distance. The buffer strips were assumed to be only 50 feet for aerial spraying and 20 feet for ground spraying. The actual residues in water would be less under more favorable spray conditions, at greater distances, or with deeper water bodies. For example, if the water were 2 feet deep then the residues would be only one-fourth of those calculated for this analysis. Dilution or degradation would also decrease residues. Herbicide doses to individuals were calculated assuming that they drink 1 liter of the maximally contaminated water.

Residues in Game Animals

Residues were calculated for two representative game animals: a 150-pound deer and a 0.25-pound game bird, such as a quail. The entire body surface area of the animal was assumed to be exposed to spray drift as shown in Table 4-7. Forty percent of the body surface was assumed to contact vegetation and thereby gain an additional average dermal residue level equal to that on the vegetation. Penetration of the herbicides through animal skin was assumed to be the same as through human skin.

The game animals were assumed to get an oral dose both by grooming and in their diet. The dose from grooming was assumed to amount to 29 percent of the nonabsorbed dermal dose for deer, and 40 percent for quail. The deer diet was assumed to consist of 2.45 kg of forage plants and 4 liters of water per day, both containing the herbicide. The quail diet was assumed to consist of 33 g of seed (grain) per day and 15 ml of water, both containing herbicide.

The concentration of herbicide in game meat was calculated by summing the animal's doses from both the dermal and oral routes of exposure and by assuming that 10 percent of that total dose was retained in the meat of the animal. This is similar to the method used in the exposure analysis of USDA (1984). Herbicide doses to humans were calculated by assuming that they eat 400 g of deer meat or 400 g of bird meat per day.

Residues in Fish

Residues in fish were calculated assuming that the fish lived in and were caught from waters 6 inches

deep, directly downwind of a treated site, with a minimum buffer strip of 20 feet for ground-based applications and 50 feet for aerial applications. For most of the herbicides considered in this analysis, which do not appreciably bioaccumulate, the concentration in fish were taken to be equal to the particular herbicide's concentrations in water. For the herbicides for which bioconcentration is likely to be greater—atrazine, diuron, and tebuthiuron—a bioconcentration factor was used. A bioconcentration factor of 10 was used for tebuthiuron, a value of 5 was used for atrazine, and a bioconcentration factor of 20 was used for diuron (Koeman et al., 1969). Doses to humans from eating fish containing herbicide were calculated assuming that 400 g are eaten daily.

Dermal Exposure

Dermal exposure due to drift was estimated by assuming that 2 square feet of skin were exposed (Dost, 1983) and the level of deposition on skin is the same as that found on the sampling sheets used in the drift monitoring studies. The dose was calculated as the deposited amount times the dermal penetration rate.

Indirect dermal exposure due to contact with foliage with surface residues of drifted herbicide was calculated by using the "unified field model" of Popendorf and Leffingwell (1982) and Popendorf (1985). This model was developed to estimate the possible doses and effects of insecticides on agricultural workers. The model was applied to estimate the relatively heavy exposures that could result from extensive foliage contact, such as that which would be experienced in berrypicking. The model takes into account:

1. The residue on foliage at any point in time after application (This analysis assumes no decay after initial application.)

2. A crop-specific residue transfer coefficient (cm^2 /hr).

3. The exposure period in hours.

4. The dermal penetration rate for each herbicide and the body mass of a human (50 kg).

The residue transfer coefficient has been determined for a few agricultural situations. The value of 1,600 cm^2/hour for this coefficient was used in this analysis to estimate doses to berry pickers. This value, derived from data collected for grape harvesting (Popendorf, 1985), represents a relatively high exposure situation. People engaged in activities involving less foliage contact, for example, tree planting, can be expected to receive doses that are considerably less. People who contacted foliage after the initial application also receive reduced doses due to degradation of the herbicides (see Table 4-10).

Dermal doses due to incidental contact with foliage, represented in the scenarios by vegetation contact for the hiker, were estimated by another method. Lavy et al. (1980) measured the level of 2,4,5-T on cloth patch samplers attached to a person who walked through a treated forest area. The residues were less than the detection limit of 0.01 mg per 100 cm^2 patch, but in this analysis a conservative assumption was made that the residues were at the detection limit. The area of clothing contacting foliage was assumed to be 40 percent of the total human surface area, and 10 percent of the total area was assumed to be bare skin contacting foliage. The same dermal penetration rates discussed previously were applied to bare skin, but the penetration through clothing was assumed to be 30 percent over a 6-hour period, based on work by Newton and Norris (1981).

Estimation of Doses to Workers and the Public from Accidents

The following scenarios were used to estimate the worst case doses that would result from the exposure to high amounts of herbicide that could occur in accidents.

1. **Accidental Spraying.** Members of the public are accidentally sprayed with herbicide because they are beneath a spray aircraft or too close to a truck or backpack applicator. (This dose would also apply to workers.) Indirect exposures to the same categories of people examined in the routine scenario are also estimated here. However, in the accidental-worst case spraying scenario, all items that they eat, drink, or brush against are sprayed at the full application rate, not just through drift.

2. **Spills.** Members of the public receive herbicide exposure via drinking water when a load of herbicide mixture is spilled or when a container of herbicide concentrate breaks open and spills into a drinking water supply. Workers spill concentrate or prepared spray mixture on their skin during mixing, loading, or spraying operations; or are doused when a transfer hose breaks.

Accidental dermal doses were derived from modeling the dermal penetration of herbicide concentrate or mixture for direct exposures. Accidental ingestion doses were estimated by modeling the dilution of herbicide concentrate or mixture in a body of water of a given size.

To calculate the dose to a person directly sprayed at the full per-acre application rate, the worst case

application rates shown in Table 4-3 were converted to mg/ft². It is assumed that 2 square feet of human skin is exposed (Dost, 1983).

Reentry exposure to the general public is estimated assuming an individual walks through a treated area after an operation has been completed, even though the area is posted. Reentry exposure is also calculated for an individual who picks berries for 4 hours in a treated area, even though the area is posted. Accidental dietary exposure is derived by assuming an individual eats food items that have been directly sprayed rather than food items receiving only spray drift, or eats meat from animals that have fed directly on sprayed vegetation or fish taken from directly sprayed water bodies or drinking water from those water bodies.

An individual receives an accidental ingestion exposure resulting from a major spill by drinking water from a pond or a reservoir that has been contaminated by a dump of 100 gallons of herbicide mix as from a helicopter, or 1,000 gallons of spray mix from a batch truck. One thousand gallons is approximately the largest amount of spray mix that might be carried by a tank truck supplying a large aerial spraying operation. One hundred gallons is approximately the largest load that can be carried by the types of helicopters currently used in the Pacific Northwest. The maximum herbicide concentrations in drums and batch trucks are shown in Table 4-8. The pond is assumed to be 1 acre in area and 4 feet deep, and to have no inflow or outflow. The reservoir is assumed to be 16 acres in area and 8 feet deep. A person is assumed to drink 1 liter of water after complete mixing has occurred.

Direct dermal exposures were calculated for spills of 0.5 liter of herbicide concentrate (if liquid concentrates are used) or 0.5 liter of the most concentrated spray mixture. The person exposed during the spill is assumed to weigh 50 kg, and most of his surface area (0.8 m^2 or 8.6 ft^2) is thoroughly wetted by the solution. Denim fabric commonly used in clothing retains about 57.5 ml of solution per square foot (Weeks, 1985), and absorption of herbicide through the cloth was calculated as before, based on Newton and Norris (1981). However, 20 percent of the solution was assumed to wet bare skin. A spill resulting in this exposure could result from broken hoses, spilled containers, or emergency and accidental dumps by helicopters.

Estimation of Lifetime Doses to Workers and the Public

Doses used in the cancer risk analysis for 2,4-D, 2,4-DP, picloram, amitrole, asulam, bromacil, and glyphosate (discussed in Section 5) were derived by combining available information on the number of days per year an individual worker may spray an herbicide using a particular application method, and estimates of the expected daily dose and the number of years of employment. Expected daily doses were calculated assuming that the worst case dose is experienced 5 percent of the time and the realistic dose 95 percent of the time, in all routine scenarios. The realistic cases assume that workers are employed in pesticide application for 5 years, and the worst cases assume 20 years employment in herbicide applications.

Table 4-8
Maximum Herbicide Concentrations in Drums and Batch Trucks

Herbicide	Pounds per Gallon Concentrate	Pounds per 50-Gallon Drum	Pounds per 1,000-Gallon Batch Tank
Amitrole	2.00	100.0	400.0
Asulam	4.00	200.0	334.0
Atrazine	4.00	200.0	400.0
Bromacil	4.00	200.0	200.0
2,4-D	4.00	200.0	400.0
2,4-DP	6.00	300.0	250.0
Dalapon	-- a	--	1,000.0
Dicamba	4.00	200.0	400.0
Diuron	4.00	200.0	320.0
Fosamine	4.00	200.0	1,200.0
Glyphosate	3.00	150.0	500.0
Hexazinone	2.00	100.0	300.0
Picloram	2.00	100.0	500.0
Simazine	4.00	200.0	500.0
Tebuthiuron	--	--	600.0
Triclopyr	4.00	200.0	800.0

[a]Not purchased in liquid formulation by the Forest Service or BLM.

Average numbers of exposures per lifetime were used with expected daily doses for each scenario to derive realistic lifetime doses. Extreme lifetime doses were derived by multiplying expected daily dose levels estimated in worker scenarios by estimates of the highest number of days a worker is likely to be engaged in the particular type of application method. Exposures per lifetime in the realistic scenarios were estimated to be the following: aerial, 30; right-of-way, 45; backpack, 50; and hand application, 70. For the routine-worst case scenario doses, the number of exposures per lifetime were: aerial, 288; right-of-way, 416; backpack, 440; and hand application, 480.

Lifetime exposures to the public for the five herbicides were derived by assuming a realistic estimate would be a single exposure per lifetime in each of the public exposure scenarios, and a high estimate would be one exposure per year for 30 years. The exposure levels derived in the realistic and extreme public scenarios and on accidental

spraying and spills were multiplied by 1 for realistic lifetime and 30 for extreme lifetime doses.

Effect of Body Size on Exposure

All doses estimated in the exposure analysis were calculated for a representative 50-kg person. This weight was chosen to represent an adult of less than average weight, so that doses to adults would be calculated in a conservative manner. Doses for a larger person would be less in terms of mg per kg body weight. For example, a 70-kg person would receive approximately 25 percent more herbicide than a 50-kg person by dermal exposure, because of his greater surface area. A 70-kg person would also receive on average about 25 percent more herbicide by dietary exposure routes, because both body surface area and metabolism are approximately proportional to body weight raised to the 2/3 power:

$$\frac{(70)^{2/3}}{(50)^{2/3}} = 1.25$$

However, a 70-kg person also has a body weight greater than a 50-kg person, by a greater factor:

$$\frac{70}{50} = 1.4$$

The combined effect of these two factors is that a 70-kg person will receive a dose in mg/kg that is only 89 percent as great as for a 50-kg person.

Conversely, smaller people can be expected to receive greater doses in terms of mg per kg body weight. A 20-kg child will receive only about 54 percent as much herbicide as a 50-kg person, but his weight is only 40 percent as great. The net effect is that a 20-kg child will receive a dose that is 36 percent greater in terms of mg/kg than it would be for a 50-kg person.

Table 4-9 illustrates the effect of body size on expected dose. The table shows doses for a 20-kg child and 50- and 70-kg adults for each route of exposure in the extreme aerial application scenario.

Time Dependence of Dermal Exposure Due to Vegetation Contact

Herbicide residues on plant surfaces decline over time as a result of absorption by the plant, degradation, volatilization, and washing by rainfall. After herbicide sprays dry on plant surfaces they cannot be completely rubbed off because of binding to the plant surface materials. Consequently, persons entering a treated area a short time after spraying are likely to receive dermal doses much smaller

Table 4-9
Effect of Body Size on Dose:
2,4-D Aerial Routine-Worst Case Scenario
(doses in micrograms/kg)

Exposure Route	20-kg Child	50-kg Adult	70-kg Adult
Drift, Dermal	13.86	10.19	9.07
Veg. Contact, Hiker	0.20	0.15	0.13
Veg. Contact, Picker	35.72	26.27	23.38
Drinking Water	17.25	12.68	11.29
Eating Berries	14.18	10.42	9.28
Eating Vegetables	28.35	20.85	18.55
Eating Deer Meat	2.16	1.59	1.41
Eating Game Bird	9.20	6.77	6.02
Eating Fish	6.90	5.07	4.51

than the conservative doses calculated in this analysis. However, specific data were not available for most of the 16 herbicides regarding persistence on plant surfaces. The most appropriate data would be measurements of dislodgable residues, but this type of data was not available for the herbicides. In most casesm measurements of the total plant residues oveer time were available, so this data has been used to calculate degradation rates in those cases where surface measurements were unavailable. Degradation rates calculated in this way should be considered minimum degradation rates for dislodgeable residues, because the residues that were measured in deriving the data may have been largely or entirely unavailable for dermal exposure through vegetation contact.

Table 4-10 shows the dermal exposures calculated for a hiker and a person picking berries for 4 hours on a treated site. The table shows the doses at the first day and also after 30 and 90 days. The doses decline dramatically even with these minimum rates of degradation. In the case of bromacil, no degradation rate was found in the available literature, so a minimal degradation rate corresponding to a half life of 60 days was used. The actual rate of degradation is likely to be greater.

Even the 90-day time period is considerably less than the minimum period between treatment for site preparation and reentry for tree planting. Vegetation contact for tree planters is also much less than for berrypickers, so the maximum dose for planters will be significantly less.

Exposure Analysis Results

This subsection presents the results of the exposure analysis. Doses to workers and the public estimated for routine operations and for accidents

Table 4-10
Doses Due to Vegetation Contact on a Treated Site (micrograms/kg)

Herbicide	Degradation Rate per Day	Hiker Day 1	Hiker Day 30	Hiker Day 90	Berrypicker Day 1	Berrypicker Day 30	Berrypicker Day 90
Amitrole	0.0866	12.0	0.9	0.0	7168.0	533.5	3.0
Asulam	0.0110	4.2	3.0	1.6	2508.8	1803.6	932.2
Atrazine	0.0621	15.0	2.3	0.1	8960.0	1390.6	33.5
Bromacil	0.0116	18.0	12.7	6.3	10752.0	7592.0	3785.2
2,4-D	0.0431	2.0	0.6	0.0	1225.7	336.4	25.3
2,4-DP	0.0431	3.0	0.8	0.1	1792.0	491.8	37.0
Dalapon	0.0542	18.0	3.5	0.1	10752.0	2115.1	81.8
Dicamba	0.0578	4.8	0.8	0.0	2867.2	506.3	15.8
Diuron	0.2740	35.9	0.0	0.0	21504.0	5.8	0.0
Fosamine	0.0990	7.2	0.4	0.0	4300.8	220.5	0.6
Glyphosate	0.0495	3.0	0.7	0.0	1792.0	405.9	20.8
Hexazinone	0.0584	7.2	1.2	0.0	4300.8	745.9	22.4
Picloram	0.0693	0.0	0.0	0.0	18.6	2.3	0.0
Simazine	0.0455	2.8	0.7	0.0	1648.6	421.0	27.5
Tebuthiuron	0.0834	4.8	0.4	0.0	2867.2	234.9	1.6
Triclopyr	0.3120	4.8	0.0	0.0	2867.2	0.2	0.0

are summarized and discussed. Complete dose estimates are presented in Attachment B.

Doses to Workers

Realistic Worker Doses in Routine Operations

Routine-realistic worker doses are summarized in Table 4-11. No worker in any of the realistic scenarios receives a dose of any herbicide greater than 1.0 mg/kg. All backpack workers receive doses greater than 0.1 mg/kg except those using amitrole, dicamba, and picloram. Helicopter mixer-loaders receive atrazine, dalapon, and simazine doses greater than 0.1 mg/kg, but all other doses in the realistic aerial scenario for mixer-loaders, pilots, supervisors, and observers are less than 0.1 mg/kg. Bromacil, 2,4-DP, diuron, fosamine, and triclopyr doses to hack-and-squirt applicators are greater than 0.1 mg/kg. All other hand application doses are less than 0.1 mg/kg.

Worst Case Worker Doses in Routine Operations

In the routine-worst case worker application scenarios (summarized in Table 4-12), doses to aerial supervisors and observers, right-of-way applicators, and injection-bar applicators are all less than 1.0 mg/kg. Doses of dalapon, fosamine, tebuthiuron, and triclopyr exceed 1.0 mg/kg for pilots and mixer-loaders in the aerial scenario. Doses of simazine and glyphosate to mixer-loaders also exceed 1.0 mg/kg. All herbicide doses to backpack workers exceed 1.0 mg/kg except for amitrole and picloram. Hack-and-squirt applicator doses of bromacil, 2,4-DP, diuron, fosamine, and triclopyr all exceed 1.0 mg/kg. All other doses are less than 1.0 mg/kg.

Doses to the Public

Doses via Individual Exposure Routes

Doses to the public via specific exposure routes in the three routine-realistic scenarios are shown in Attachment B. In none of the routine-realistic scenarios does the public receive a dose greater than 0.01 mg/kg (10 micrograms/kg) for any of the 16 herbicides through any single exposure route. Doses are lowest (less than 0.006 micrograms/kg) to the hiker who contacts vegetation with herbicide residues. Doses are highest for the ingestion routes of exposure, particularly drinking water and eating berries or garden vegetables.

Doses to the public via individual exposure routes in the routine-worst case scenarios also are shown in Attachment B. No dose to the public is greater than 0.01 mg/kg for any chemical through any exposure route in either the truck (right-of-way) or backpack scenarios. Highest public doses occur in the routine-worst case aerial scenario, in particular, for the berrypicker contacting vegetation, where the

Table 4-11
Worker Doses for Routine-Realistic Scenarios

Herbicide	Aerial						Truck		Hand Application	
	Pilot	Mix/L	Sup	Obs	Backpack	Appl	Mix/L	App M/L	Hack/ Squirt	Inj Bar
Amitrole	0	0	-1	-1	1	-1	-1	-1	0	0
Asulam	2	2	1	1	3	1	1	2	--	--
Atrazine	2	3	2	1	3	2	2	2	--	--
Bromacil	--	--	--	--	3	2	2	2	3	2
2,4-D	2	2	1	0	3	1	1	1	2	2
2,4-DP	2	2	1	0	3	1	1	1	3	2
Dalapon	2	3	2	1	3	2	2	2	--	--
Dicamba	2	2	1	0	2	1	1	1	2	2
Diuron	--	--	--	--	3	2	2	2	3	2
Fosamine	2	2	1	1	3	2	2	2	3	2
Glyphosate	2	2	1	1	3	1	1	1	--	--
Hexazinone	2	2	1	1	3	1	1	2	--	--
Picloram	0	1	0	-1	1	0	0	0	1	1
Simazine	2	3	2	1	3	1	1	1	--	--
Tebuthiuron	2	2	1	0	3	1	1	2	--	--
Triclopyr	2	2	1	1	3	1	1	1	3	2

Legend
4 10.0 mg/kg
3 1.0 mg/kg (less than 1 milligram/kg)
2 0.1 mg/kg
1 0.01 mg/kg
0 0.001 mg/kg (less than 1 microgram/kg)
-1 0.0001 mg/kg
-2 0.00001 mg/kg
-- herbicide not used in this scenario

Table 4-12
Worker Doses for Routine-Worst Case Scenarios

Herbicide	Aerial						Truck		Hand Application	
	Pilot	Mix/L	Sup	Obs	Backpack	Appl	Mix/L	App M/L	Hack/ Squirt	Inj Bar
Amitrole	1	1	1	0	2	1	1	1	2	1
Asulam	3	3	2	2	4	3	3	3	--	--
Atrazine	3	3	3	2	4	3	3	3	--	--
Bromacil	--	--	--	--	4	3	3	3	4	3
2,4-D	3	3	2	2	4	3	2	2	4	3
2,4-DP	3	3	2	1	4	3	2	3	4	3
Dalapon	4	4	3	2	4	3	3	3	--	--
Dicamba	3	3	2	2	4	2	2	2	3	
Diuron	--	--	--	--	4	3	3	3	4	3
Fosamine	4	4	3	2	4	3	3	3	4	3
Glyphosate	3	4	3	2	4	3	3	3	--	--
Hexazinone	3	3	2	2	4	3	3	3	--	--
Picloram	2	2	1	1	3	1	1	1	2	1
Simazine	3	4	3	2	4	3	3	3	--	--
Tebuthiuron	4	4	3	2	4	3	3	3	--	--
Triclopyr	4	4	3	2	4	3	3	3	4	3

Dose Levels
4 10.0 mg/kg
3 1.0 mg/kg
2 0.1 mg/kg
1 0.01 mg/kg
0 0.001 mg/kg
-1 0.0001 mg/kg
-2 0.00001 mg/kg
-- herbicide not used in this scenario

Table 4-13
Doses to Example People in Routine-Realistic Exposure Scenarios

	Aerial					Truck (row)					Backpack				
Herbicide	Hiker	Berry-picker	Hunter	Fisher-man	Nearby Resident	Hiker	Berry-picker	Hunter	Fisher-man	Nearby Resident	Hiker	Berry-picker	Hunter	Fisher-man	Nearby Resident
Amitrole	1	1	1	1	1	-1	0	0	0	0	0	0	0	0	0
Asulam	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Atrazine	1	2	1	2	1	0	0	0	0	0	0	1	0	1	1
Bromacil	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1
2,4-D	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0
2,4-DP	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0
Dalapon	1	2	1	1	1	0	0	0	0	0	0	1	1	0	1
Dicamba	0	1	1	1	1	-1	0	-1	-1	0	-1	0	0	-1	0
Diuron	-	-	-	-	-	0	0	0	1	0	0	1	1	1	1
Fosamine	1	1	1	1	1	0	0	0	0	0	0	1	0	0	1
Glyphosate	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0
Hexazinone	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Picloram	0	1	1	1	1	-1	-1	-1	-1	0	-1	0	0	0	0
Simazine	1	2	1	1	1	0	0	0	0	0	0	1	0	0	0
Tebuthiuron	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0
Triclopyr	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0

Dose Levels
- - not used
2 0.01 mg/kg
1 0.01 mg/kg
0 0.001 mg/kg
-1 0.0001 mg/kg

berrypicker dose is slightly higher than 0.1 mg/kg (100 micrograms/kg) for dalapon and fosamine. It is less than 0.1 mg/kg for all the other herbicides.

Doses via Multiple Exposure Routes

Doses for people who receive combined herbicide doses of each of the 16 herbicides through the various exposure routes outlined in Table 4-6 are listed for the three routine-realistic scenarios in Table 4-13, and for the three routine-worst case scenarios in Table 4-14.

In no instance do any of the combined doses of any of the herbicides in the routine-realistic scenarios exceed 0.1 mg/kg. Those that exceed 0.01 mg/kg (berrypickers for atrazine, dalapon, and simazine; fishermen for atrazine) are all lower than 0.015 mg/kg (see Attachment B).

No representative member of the public receives a dose of any herbicide higher than 0.01 mg/kg in the routine-worst case right-of-way scenario. Dalapon and fosamine doses to berrypickers exceed 0.01 mg/kg in the routine-worst case backpack scenario. Highest public doses range from greater than 0.01 mg/kg to less than 0.3 mg/kg for combined public doses in the routine-worst case aerial scenario for all 16 herbicides. Highest public doses are from dalapon and fosamine.

Accidental Doses to Workers and the Public

Doses from Accidental Spraying

Doses to workers and members of the public from accidental spraying are listed for the 16 herbicides in Table 4-15. The table lists doses in micrograms/kg rather than mg/kg (1 mg ^{5} 1,000 micrograms). Doses exceed 1 mg/kg for berrypicker dermal exposure (reentry) for bromacil, dalapon, diuron, and fosamine. Doses of diuron from eating fish exceed 1 mg/kg. All other doses are less than 1 mg/kg.

Doses to representative members of the public from accidental spraying, listed in Table 4-16, exceed 1 mg/kg for the berrypicker for atrazine, bromacil, dalapon, hexazinone, tebuthiuron, and triclopyr. Doses of fosamine to the berrypicker exceed 2 mg/kg. Doses of diuron to the hunter and nearby resident exceed 1 mg/kg; for the berrypicker and fisherman, doses exceed 2 mg/kg. All doses of all other herbicides are less than 1 mg/kg for representative members of the public in spraying accidents.

Doses from Spills

Doses from spill accidents, both direct dermal and via drinking water, are listed in Table 4-17. The spill doses are listed in mg/kg (not micrograms/kg as in the spraying accidents). By far, the highest doses are received in worker spill accidents where workers

Table 4-14
Doses to Representative Members of the Public in Routine-Worst Case Exposure Scenarios

	Aerial					Truck (row)					Backpack				
Herbicide	Hiker	Berry-picker	Hunter	Fisher-man	Nearby Resident	Hiker	Berry-picker	Hunter	Fisher-man	Nearby Resident	Hiker	Berry-picker	Hunter	Fisher-man	Nearby Resident
Amitrole	2	2	2	2	2	0	1	0	0	1	0	1	0	0	1
Asulam	2	2	2	2	2	0	1	0	0	1	0	1	1	1	1
Atrazine	2	2	2	2	2	0	1	1	1	1	1	1	1	1	1
Bromacil	-	-	-	-	-	0	0	0	0	0	0	1	1	0	1
2,4-D	2	2	2	2	2	0	1	0	0	0	0	1	1	0	1
2,4-DP	2	2	2	2	2	0	1	0	0	1	0	1	1	1	1
Dalapon	2	3	2	2	3	1	1	1	1	1	1	2	1	1	1
Dicamba	2	2	2	2	2	0	0	0	0	0	0	1	1	0	1
Diuron	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1
Fosamine	2	3	3	3	3	1	1	1	1	1	1	2	1	1	1
Glyphosate	2	3	2	2	2	0	1	0	0	1	1	1	1	1	1
Hexazinone	2	2	2	2	2	0	1	0	0	1	0	1	1	0	1
Picloram	2	2	2	2	2	0	0	0	0	0	0	1	0	0	1
Simazine	2	3	2	2	2	0	1	0	0	1	1	1	1	1	1
Tebuthiuron	2	3	2	3	2	0	1	0	1	1	1	1	1	1	1
Triclopyr	2	3	2	2	3	0	1	1	1	1	1	1	1	1	1

Dose Levels
3 1.0 mg/kg
2 0.1 mg/kg
1 0.01 mg/kg
0 0.001 mg/kg
-1 0.0001 mg/kg

Table 4-15
Doses to the Public from Items Receiving the Full per-Acre Application Rate by Exposure Type, Accidental-Worst Case (micrograms/kg)

Herbicide	Direct Dermal	Reentry Hiker	Reentry Picker	Drink Water	Eating Berries	Eating Vegs.	Eating Deer	Eating Bird	Eating Fish
Amitrole	3	0	9	117	93	194	19	116	47
Asulam	209	3	538	73	58	121	13	83	29
Atrazine	355	5	914	125	99	206	22	141	249
Bromacil	417	6	1,075	147	116	242	26	165	59
2,4-D	103	1	264	60	48	99	10	64	24
2,4-DP	133	2	344	73	58	121	13	79	29
Dalapon	417	6	1,075	147	116	242	26	165	59
Dicamba	83	1	215	59	47	97	10	62	23
Diuron	667	10	1,720	235	186	387	42	265	1,878
Fosamine	501	7	1,290	176	140	290	31	199	70
Glyphosate	209	3	538	73	58	121	13	83	29
Hexazinone	250	4	645	88	70	145	16	99	35
Picloram	10	0	26	73	58	121	12	73	29
Simazine	209	3	538	73	58	121	13	83	29
Tebuthiuron	250	4	645	88	70	145	16	99	352
Triclopyr	334	5	860	117	93	194	21	132	47

Table 4-16
Doses for Example People[a] for Accidental-Worst Case Spraying (micrograms/kg)

Herbicide	Hiker	Berry-picker	Hunter	Fisherman	Nearby Resident
Amitrole	121	222	256	168	314
Asulam	285	878	381	314	406
Atrazine	484	1,492	647	734	690
Bromacil	570	1,755	761	628	812
2,4-D	164	475	239	188	263
2,4-DP	209	609	300	238	330
Dalapon	570	1,755	761	628	812
Dicamba	143	404	215	167	240
Diuron	912	2,809	1,218	2,790	1,299
Fosamine	684	2,107	914	754	974
Glyphosate	285	878	381	314	406
Hexazinone	342	1,053	457	377	487
Picloram	84	167	168	113	204
Simazine	285	878	381	314	406
Tebuthiuron	342	1,053	457	694	487
Triclopyr	456	1,404	609	503	649

[a]All of these people receive multiple exposures as shown in Table 4-6.

receive doses exceeding 100 mg/kg for all the herbicides except amitrole, dalapon, picloram, and tebuthiuron. Spills of mixture on workers' skin lead to estimated doses that exceed 10 mg/kg for all herbicides except amitrole, 2,4-DP, and picloram. Doses to the public from truck spills rarely exceed 1 mg/kg. Those from helicopter dumpds into a reservoir never exceed 0.01 mg/kg.

Lifetime Doses

Lifetime doses to workers and the public from herbicide spraying for a specified number of exposures over a 70-year lifetime are listed in the final set of tables in Attachment B. Cancer risk based on the specified number of exposures is discussed in Section 5.

Table 4-17
Doses from Herbicide Spills (mg/kg)

Herbicide	Spill of One Pint Concentrate on Skin	Spill of One Pint Tank Mix on Skin	Helicopter[a] Dump into Pond	Helicopter[a] Dump into Reservoir	Truck[a] Spill into Pond	Truck[a] Spill into Reservoir
Amitrole	1.20	0.24	0.0737	0.0023	0.7365	0.0230
Asulam	240.00	20.04	0.0615	0.0019	0.6150	0.0192
Atrazine	240.00	24.00	0.0737	0.0023	0.7365	0.0230
Bromacil	240.00	12.00	--	--	0.3683	0.0115
2,4-D	144.00	14.40	0.0737	0.0023	0.7365	0.0230
2,4-DP	230.40	9.60	0.0460	0.0014	0.4603	0.0144
Dalapon	--	60.00	0.1841	0.0058	1.8413	0.0575
Dicamba	120.00	12.00	0.0737	0.0023	0.7365	0.0230
Diuron	240.00	19.20	--	--	0.5892	0.0184
Fosamine	240.00	72.00	0.2210	0.0069	2.2095	0.0690
Glyphosate	180.00	30.00	0.0921	0.0029	0.9206	0.0288
Hexazinone	120.00	18.00	0.0552	0.0017	0.5524	0.0173
Picloram	5.76	1.44	0.0921	0.0029	0.9206	0.0288
Simazine	240.00	30.00	0.0921	0.0029	0.9206	0.0288
Tebuthiuron	--	36.00	0.1105	0.0035	1.1048	0.0345
Triclopyr	240.00	48.00	0.1473	0.0046	1.4730	0.0460

[a]Assuming 1 liter of water drunk per day.
-- Herbicide not used in a form that could cause this kind of spill.

Section 5
Human Health Risk Analysis

This section presents information on potential risks to the health of workers and members of the public from the proposed herbicide applications by comparing the exposure levels estimated in Section 4 with the toxic effect levels described in Section 3. The first subsection describes the methods used to evaluate risks. The second subsection evaluates the risks of threshold effects that include acute toxic effects, chronic systemic effects, and reproductive (fetotoxic and maternal toxic) and teratogenic effects. The last subsection evaluates the risks of the herbicides causing cancer or mutagenic effects in the population at risk. All judgments about risk are discussed in light of the probabilities of the estimated exposures actually occurring.

How the Risks to Workers and the Public Were Determined

In this risk analysis, the risks to humans exposed to the 16 herbicides were quantified by comparing the doses estimated in the range of exposure scenarios presented in Section 4 with the results of toxicity tests on laboratory animals described in Section 3. To quantify the risks of threshold effects, the doses estimated for exposed individuals as a result of herbicide applications are compared to laboratory-derived no-observed-effect levels (NOEL's) determined in the most sensitive animal test species. For doses that are not likely to occur more than once, such as those received by workers spilling a quart of spray mix over their entire upper body, a dose estimate that exceeds the laboratory test animal NOEL does not necessarily lead to the conclusion that there will be toxic effects. All of the NOEL's used in this risk analysis are based on (or take into account) long-term exposure. Estimated doses that exceed the NOEL are compared to the herbicide's acute oral LD_{50} , so that a judgement can be made on the risk of fatal effects.

The ratio between the animal NOEL and the estimated human dose, referred to in this analysis as the margin of safety (MOS), is used to account for the uncertainty inherent in relating doses and effects seen in animals to doses and effects seen in humans. For example, an MOS of 100 means the laboratory-determined level is 100 times higher than the estimated dose. For convenience in this analysis, the ratio between the herbicide's LD_{50} and the estimated human dose also is expressed as an MOS; however, it should not be interpreted in the same way as the MOS based on a NOEL in terms of the expectation of no effects in humans.

The larger the margin of safety (the smaller the estimated human dose compared to the animal NOEL), the lower the risk to human health. As the estimated dose to humans approaches the animal NOEL (as the MOS approaches one), the risk to humans increases. When an estimated dose exceeds a NOEL (giving an MOS of less than one), the ratio is reversed (the dose is divided by the NOEL) to indicate how high the estimated dose is above the laboratory toxicity level; a minus sign is attached to indicate that the dose exceeded the NOEL; and the result is no longer termed a margin of safety but is called simply a negative ratio.

A ratio of -3, for example, means that the estimated dose is 3 times the laboratory-determined level. A negative ratio infers that the estimated dose (given all the assumptions of the scenario) represents a clear risk of possible acute effects if the ratio is based on the LD_{50} or of possible chronic effects if the ratio is based on the systemic or reproductive NOEL.

When repeated doses to humans are higher than the animal NOEL (the MOS is less than one), there is some possibility of harmful effects. Conversely, when the human dose is small compared with the animal NOEL (giving an MOS greater than 100), the risk to humans can be judged negligible. Comparing one-time or once-a-year doses (such as those experienced by the public) to NOEL's derived from lifetime studies tends to greatly overestimate the risk from those rare events.

Systemic effects are evaluated based on the lowest systemic NOEL found in a 2-year feeding study of dogs, rats, or mice. (When subchronic studies reported effects at lower levels than chronic studies, the subchronic NOEL's were used.) Reproductive effects are evaluated based on the lowest maternal, fetotoxic, or teratogenic NOEL found in a three-generation reproductive study or in a teratology study.

A worst case analysis of cancer risk is conducted for the herbicides for which there are positive cancer studies, amitrole, asulam, bromacil, picloram, and 2,4-DP, and for herbicides for which there is scientific controversy about their ability to cause cancer, such as 2,4-D and glyphosate. The risk of cancer is calculated for an individual by comparing estimates of lifetime dose over a 70-year period (computed in Section 4) with cancer potency estimates derived in the Hazard Analysis section. A

worst case analysis is also conducted for those herbicides that have positive mutagenicity tests or those for which no data is available. The risk of these herbicides causing mutations is qualitative rather than quantitative, with a statement of the probable risk based on the available evidence of mutagenicity and carcinogenicity.

Risk of General Systemic and Reproductive Effects

For each application scenario, routine-realistic, routine-worst case, and accidental worst case assumptions were used to compute margins of safety for workers and the public for all 16 herbicides. Complete tables for each herbicide are given in Attachment C. The margins of safety were computed by comparing the laboratory-determined NOEL's and LD_{50}'s in Table 5-1 with the doses shown in Attachment B.

Risk to the Public Under Routine Operations

Table 5-2 summarizes the margin-of-safety results for the public for the 16 herbicides under both the routine-realistic and routine-worst case exposure scenarios.

Risk to the Public Under Routine-Realistic Scenarios

Margins of Safety for the Public Under Routine-Realistic Scenarios. Table 5-2 shows that there are large margins of safety (greater than 150) for every category of exposure—even cumulative exposures—under the routine-realistic scenario for asulam, atrazine, bromacil, 2,4-D, 2,4-DP, dalapon, dicamba, diuron, fosamine, glyphosate, hexazinone, picloram, simazine, and tebuthiuron, and triclopyr. Although the public should not be chronically exposed to these herbicides (indeed, given the remote location of most spray areas, it is unlikely that any member of the public will be exposed at all), these large margins of safety mean that they could be repeatedly exposed to these levels, or cumulatively exposed to these levels, and suffer no adverse effects. This is true for all individuals including pregnant women and the vast majority of sensitive individuals.

Table 5-1
Toxicity and Cancer Potency of Herbicides

Herbicide	Rat LD_{50} mg/kg	Systemic NOEL mg/kg/day	Reproductive/ Terat. NOEL mg/kg/day	Cancer Potency per mg/kg/day
Amitrole	4,060.00	0.025	5.0	1.4
Asulam	4,000.00	50.0	50.0	0.02
Atrazine	1,869.00	3.7	100.0	0
Bromacil	3,998.00	6.25	7.92	0.0038
2,4-D	375.00	1.0	25.0	0.0050
2,4-DP	532.00	5.0	6.25	0.059
Dalapon	7,577.00	15.0	300.0	0
Dicamba	757.00	25.0	2.5	0
Diuron	3,750.00	0.625	6.25	0
Fosamine	24,400.00	25.0	750.0	0
Glyphosate	4,320.00	30.0	10.0	0.000024
Hexazinone	1,690.00	10.0	125.0	0
Picloram	8,200.00	7.0	50.0	0.00057
Simazine	5,000.00	5.0	5.0	0
Tebuthiuron	644.00	12.5	90.0	0
Triclopyr	630.00	2.5	10.0	0

Amitrole has many situations where the margin of safety is less than 20 for systemic effects. (The margin of safety for reproductive effects is greater than 1,000—indicating negligible risk for reproductive effects.) The greatest risk under the aerial application scenario is for individuals who drink a liter of water from a shallow stream 50 feet from the treatment area immediately after application, or eat vegetables from within 600 feet of the treatment area immediately after application. For this reason, all of the amitrole cumulative exposures for the berrypicker, hunter, fisherman, and residents are less than 10. This indicates that people chronically exposed to these levels of amitrole could experience thyroid problems. The large ratios compared to the LD_{50} indicate very little chance of acute effects.

The greatest risk by exposure route occurs in contacting vegetation that has just been sprayed with one of the herbicides while picking berries and in eating vegetables that have received spray drift. Because of this, the representative members of the public at greatest risk from any of the herbicides are the nearby resident and the berrypicker. Exposure routes leading to least risk are direct dermal exposure to spray drift, drinking water with drift residues, and eating animals or fish that have drift residues. Persons at least risk are the hunter, hiker, and fisherman. These relationships hold for all 16 herbicides.

MOS's for all herbicides estimated in the three routine-realistic public exposure scenarios are given in Attachment C. MOS's for the three most heavily used herbicides, 2,4-D, glyphosate, and triclopyr begin in Tables C-57, C-93, and C-123, respectively.

Probability of Estimated Routine-Realistic Public Doses Occurring. Although these three scenarios represent what can happen under routine operations, the probability of people receiving doses as high as those projected here is quite low.

There are no residents, hikers, fishermen, or berrypickers in the vicinity of the vast majority of treatment units. Additional precautions, such as posting

Table 5-2
Lowest Margins of Safety for the General Public Under the Routine Scenarios

Herbicide	Routine-Realistic Scenarios	Routine-Worst Case[a] Scenarios
Amitrole	All right-of-way and most backpack MOS's are greater than 50, except eating vegetables (41), and residents (32). Most MOS's for aerial application are less than 50, including the following that are less than 10: berrypicker (8),hunter (9), fisherman (9),and residents (6).	Many of the right-of-way and 2 of the backpack MOS's are less than 50. Most of the aerial MOS's are less than 50, including the following that are less than 10: drinking water (2), eating berries (2), eating vegetables (1), eating bird (4), eating fish (4), hiker (1), berrypicker (1), hunter (1), fisherman (1), and resident (-1).
Asulam	All situations greater than 6,600.	All situations greater than 700.
Atrazine	All situations greater than 310.	All situations greater than 50 except for berrypickers (44), for the 400-acre aerial application.
Bromacil	All situations are greater than 2,200.	All situations are 700 or greater.
2,4-D	All situations greater than 150.	All right-of-way and backpack MOS's are greater than 380. All aerial MOS's are greater than 10 with the following situations having MOS's of 10 to 50: vegetation contact by picker (38), eating vegetables (48), hiker (43), berry picker (17), hunter (32), fisherman (36) and resident (23).
2,4-DP	All situations 990 or greater.	All situations greater than 120.
Dalapon	Greater than 1,100 in all situations.	All situations greater than 70.
Dicamba	Greater than 1000 in all situations.	All situations greater than 100 except for berrypickers (46), hunters (84), fishermen (94), and residents (60) for 400-acre aerial application.
Diuron	Greater than 180 in all situations.	Greater than 75 in all situations.
Fosamine	All greater than 2,600.	All 99 or greater.
Glyphosate	All greater than 1,500.	All 95 or greater.
Hexazinone	All greater than 1,200.	All greater than 150.
Picloram	All greater than 3,400.	All greater than 150.
Simazine	All greater than 390.	All greater than 50 except for berrypickers (48) in 400-acre aerial application.
Tebuthiuron	All greater than 2,500.	All greater than 90.
Triclopyr	All greater than 390.	All situations greater than 50 except for vegetation contact by hiker (29), berry picker (15), hunter (32), fisherman (36), and resident (35) in 400-acre aerial application.

[a]A margin of safety of 50 was chosen as the cutoff to report values in this table for ease of comparison. It was not intended to indicate what would be considered low or high risk.

the area, are normally used to ensure that no one would be exposed during or immediately after a herbicide application operation.

Moreover, as described in Section 4, these routine-realistic scenarios use a number of conservative assumptions that tend to overestimate rather than underestimate what is expected in the majority of operations. For example, predicted levels in water (which determine doses for drinking water, eating fish, and all of the cumulative exposures) are 100 times higher than levels seen in extensive field testing. Extensive monitoring studies conducted by the Forest Service for phenoxy herbicides from 1974 to 1978 showed negligible levels of herbicides in streams (all were less than 0.04 parts per million). These extremely low levels were found despite the fact that during the 1974-78 period not all herbicide applications were monitored. Only those applications most likely to result in significant residues or cause for public concern were actually monitored (USDA, 1980).

The levels predicted on berries are also higher than those found in similar forest plants (USDA, 1984). In addition, the levels predicted for deer in the routine-realistic scenario are similar to the **highest** levels found by Newton and Norris (1968, as cited in Dost, 1983), who did not find levels greater than 0.08 parts per million in edible deer tissues.

Risk to the Public Under Routine-Worst Case Scenarios

The routine-worst case scenarios described in Section 4 were intended to indicate the upper bound for public exposure to herbicide applications in the Pacific Northwest. The low probability of each assumption, which would apply to all of the events that led to the exposures described in Table 5-2, must be emphasized. It is extremely unlikely that anyone would receive a dose as high as those estimated here.

Margins of Safety Under Routine-Worst Case Scenarios. Table 5-2 indicates that most margins of safety projected under this routine-worst case scenario are greater than 50 except for amitrole, 2,4-D, and triclopyr. Under these extreme assumptions, risk to individuals is very low except for people who receive multiple exposures from a 400-acre fixed wing application. Amitrole has a number of situations where the margin of safety is less than 10. For amitrole, people repeatedly receiving doses as high as predicted here over a long period could experience thyroid problems. Margins of safety calculated for combined routes of exposure to 2,4-D and triclopyr were all within 10 to 50 in the worst case aerial application. Chronic doses of 2,4-D, as predicted by this analysis, could affect the peripheral nervous system which, in most cases, would be a reversible effect. For triclopyr, people who chronically receive doses predicted here could experience kidney problems. Because the margins of safety were computed by comparing acute exposures with chronic no-effect levels, the risk of occurrence of these effects can be considered extremely low, especially considering the extreme unlikelihood of nearby residents receiving repeated doses over the long term.

The margins of safety computed for the residents in the worst case 400-acre aerial spray site indicate that sensitive individuals could suffer some acute toxic effects from the predicted exposures to amitrole, atrazine, 2,4-D, dicamba, simazine, and triclopyr. For atrazine, all margins of safety are greater than 50 except for a berrypicker who is dermally exposed for 4 hours, eats 0.9 pounds of berries and drinks a liter of water contaminated at the highest possible level. This person, as well as the people who receive multiple exposures to dicamba and simazine listed in Table 5-2, could experience some systemic effects. However, that is unlikely because these are one-time doses and are all more than 10,000 times lower than the LD_{50}. It should be noted that the systemic NOEL for atrazine is based on weight loss in dogs. Therefore, sensitive individuals could become ill and possibly experience stomach problems. For simazine, no toxic effects were seen at the highest dose tested in two chronic exposure studies. Therefore, any toxic effects resulting from these routine-worst case doses should be limited if any.

Public MOS's for all 16 herbicides are presented in Attachment C. MOS's for the doses estimated in the routine-worst case public exposure scenarios for the three most heavily used herbicides—2,4-D, glyphosate, and triclopyr—begin in Tables C-60, C-96, and C-126, respectively.

Probability of the Routine-Worst Case Doses Occurring. The probability of someone receiving a dose as high as those predicted under the routine-worst case scenario is negligible. The probability is low because this scenario assumes that a number of unlikely events occur simultaneously. For example, using the assumptions that the probability of treating a unit as big as 400 acres is 1 in 100, and the probability of the high drift case is 1 in 100, and the probability of someone being in the vicinity of the treatment area is 1 in 100, then the probability of someone receiving a dose as high as those predicted here is 1 in 1 million ($0.01 \times 0.10 \times 0.01 = 0.000001$). In fact, historical records indicate that the probability of these events occurring simultaneously is less than this.

Risk to the Public Under Accidental Scenarios

Table 5-3 summarizes the risk to the public from direct exposure to aerial applications or from eating food or drinking water that has been directly hit at the highest application rate. The relatively low margins of safety for amitrole, atrazine, bromacil, 2,4-D, diuron, and triclopyr indicate that people exposed to a direct aerial application or exposed to items that received the highest application rate could experience some toxic effects. The extent of effects would depend upon their duration of exposure and any precautionary measures that were taken. For example, if people gathered a bushel of berries from a spray area and did not wash them but froze them and then ate them every day for a month, they might feel quite ill. However, if people bathed after being in the forest or washed food items before eating them, the doses would drop (and thus increase the margins of safety) substantially.

The risk of a member of the public being directly hit by an aerial spray operation is very small. The probability of a pesticide application in an area not scheduled for treatment is low. According to the Forest Service data on insecticide application (USDA, 1984), the probability, based on empirical data, of some kind of significant error in a pesticide application is 0.0002 (at the 95-percent confidence level). Operational features of herbicide operations make the probability of applying a herbicide in an area not scheduled for treatment less than that of insecticide operations. Using this value as an extremely conservative estimate of the probability of an application directly hitting a human being, there might be three accidents over a period of 8 years if a spraying operation occurred every day for 6 months during each of those years. In addition, the probability that someone will be in the area being sprayed is very low because normally the area is posted before spraying and humans will be kept out of the treated areas during spray operations. Thus, the probability of such accidents can be considered negligible.

Again it must be noted that these are one-time, rather than repeat or chronic, exposures and that the comparison of these doses with the acute LD_{50}'s shows that no one is at risk of fatal effects. Complete margins of safety computed for each chemical and application under the accidental worst-case scenario are presented in Attachment C.

Table 5-3
Margins of Safety Less Than 10 for the General Public in the Accidental-Worst Case Scenarios

Herbicide	MOS Less Than 10	
	Full Application Rate	Spill
Amitrole	All exposures except vegetation contact by the hiker are less than 10. In 10 cases the doses exceed the NOEL.	Truck spill into reservoir. Doses from helicopter and truck spill into pond both exceed the NOEL.
Asulam	None less than 10 for either scenario.	
Atrazine	Vegetation contact by picker, hiker, berrypicker, hunter, fisherman, and resident.	Truck spill into pond.
Bromacil	Vegetation contact by picker, berrypicker, hunter, fisherman, and resident.	None less than 10.
2,4-D	Vegetation contact by hiker, berry picker, hunter, fisherman, and resident.	Truck spill into pond.
2,4-DP	Only the berrypicker is less than 10.	None less than 10.
Dalapon	Only the berrypicker MOS is less than 10.	Truck spill into pond.
Dicamba	Cumulative exposure of the berrypicker.	Truck spill into pond.
Diuron	All margins of safety, except hiker vegetation contact and person eating deer are less than 10. In eight cases the doses exceed the NOEL.	Truck spill into pond.
Fosamine	None less than 10 for either scenario	
Glyphosate	None less than 10 for either scenario.	
Hexazinone	Only the berrypicker MOS is less than 10.	Truck spill into pond.
Picloram	None less than 10.	Truck spill into pond.
Simazine	Berrypicker vegetation contact and berrypicker.	Truck spill into pond.
Tebuthiuron	None less than 10 for either scenario.	
Triclopyr	Vegetation contact by the berrypicker, hiker, hunter, fisherman, and the resident.	Truck spill into pond.

Risk to the Public from Herbicides Used in Brown and Burn Operations

Brown and burn operations are conducted on approximately 500 to 1,500 acres of Forest Service and BLM land every year. These operations are generally limited to the coast range of Oregon on brushy hardwood vegetation and often steep terrain. 2,4-D accounts for approximately 75 percent of the total herbicide used during this type of operation. Glyphosate and triclopyr are used to a much lesser extent. Typically, the selected herbicide is applied aerially in the fall and the vegetation is not burned until the following spring, approximately 5 to 7 months later. The treatment units average approximately 30 acres. Crew size at any given site may vary from 10 to 26 workers during the burning operation.

To estimate worker exposure during these operations, it is necessary to calculate the amount of herbicide that will be remaining on the vegetation at the time of burning. The half-lives for 2,4-D, glyphosate, and triclopyr are 16, 14, and 18 days, respectively. Therefore, after 5 months (150 days), only traces of the amount of applied herbicides would remain on the vegetation: 0.156 percent 2,4-D, 0.0596 percent glyphosate, and less than 0.33 percent of triclopyr.

The following assumptions were used to calculate potential worker exposure to smoke:

1. 32 metric tons (32,000 kg) of fuel per acre
2. 40 percent of the available fuel by weight is burned
3. Smoke density is 5 mg/m^3 (visibility 100 m)
4. 8.5 g smoke/kg of fuel burned
5. 30 acres per average treatment unit
6. All herbicide residue is released to the atmosphere upon burning
7. Respiration rate for workers at moderate work is 29 liters per minute or 1.74 m^3 per hour

32,000 kg/acre * 0.40 = 13,000 kg of fuel per acre

13,000 kg * 8.5g/kg = 110,000 g of smoke produced per acre

110,000 g/(5mg/ m^3) = 22,000,000 m^3 of smoke per acre

22,000,000 m^3 * 30 acres = 6.6 x 10^8 m^3 of smoke per treatment unit

2,4-D. The number of kilograms of 2,4-D applied at 5.7 lb/acre is: 5.7 lb / (2.2 lb/kg) = 2.6 kg

The amount of 2,4-D available after 5 months is: 2.6 kg * 1.56 x 10^{-3} = 4.1 x 10^{-3} kg (4.1 x 10^3 mg) of 2,4-D per acre (or 1.2 x 10^5 mg per treatment unit).

The atmospheric concentration of 2,4-D is: 4.1 x 10^3 mg / 2.2 x 10^7 m^3 = 1.9 x 10^{-4} mg/m^3

The expected dose of 2,4-D for an average worker (50 kg body weight) respiring at a rate of 1.74 m^3 /hour is: (1.9 x 10^{-4} mg/m^3 * 1.74 m^3 /hour) / 50 kg = 6.6 x 10^{-6} mg/kg/hour.

This is far below the NOEL of 1.0 mg/kg/day. A 1-hour-per-day exposure to smoke of this density is a reasonable expectation. If a worker were exposed to 3 hours of smoke per day, the dose would be only 3 times greater than that calculated and would still be well below the NOEL. A worker is not typically exposed to brown and burn operations more than 12 days per year. Therefore, the overall health risk from this type of operation with 2,4-D is negligible.

Glyphosate. The number of kilograms of glyphosate applied at 5.0 lb/acre is:

5.0 lb / (2.2 lb/kg) = 2.3 kg

The amount of glyphosate available after 5 months is: 2.3 kg * 5.96 x 10^{-4} = 1.4 x 10^{-3} kg (1.4 x 10^3 mg) of glyphosate (or 4.2 x 10^4 mg per treatment unit).

The atmospheric concentration of glyphosate is: 1.4 x 10^3 mg / 2.2 x 10^7 m^3 = 6.4 x 10^{-5} mg/m^3

The expected dose of glyphosate for an average worker (50 kg body weight) respiring at a rate of 1.74 m^3 /hour is: (6.4 x 10^{-5} mg/m^3 * 1.74 m^3 /hour) / 50 kg = 2.2 x 10^{-6} mg/kg/hour. This dose is well below the NOEL of greater than 30 mg/kg/day and should pose no risk to health.

Triclopyr. The number of kilograms of triclopyr at a maximum application rate of 8.0 lb/acre to is: 8.0 / (2.2 lb/kg) = 3.6 kg

The amount of triclopyr available after 5 months is: 3.6 kg * 3.3 x 10^{-3} = 1.2 x 10^{-2} kg (1.2 x 10^4 mg) of triclopyr (or 3.6 x 10^5 mg per treatment unit).

The atmospheric concentration of triclopyr is: 1.2 x 10^4 mg / 2.2 x 10^7 m^3 = 5.4 x 10^{-4} mg/m^3

The expected dose of triclopyr for an average worker (50 kg body weight) respiring at a rate of 1.74m 3 / hour is: (5.4 x 10^{-4} mg/m^3 * 1.74 m^3 /hour) / 50 kg = 1.9 x 10^{-5} mg/kg/hour. This dose is insignificant and is far below the NOEL of 2.5

mg/kg/day. No adverse health effects are expected.

Combustion Products. Wall et al.(1984) studied the pyrolysis products of 2,4-D and glyphosate. At 800 degrees Celsius 2,4-D volatilized and condensed upon cooling. Approximately 2.5 percent was converted to 2,4-dichlorophenol. No other significant pyrolysis products were formed.

Temperatures during the burning of vegetation are expected to reach at least 1,000 degrees Celsius, which could cause considerable breakdown of the herbicides (Kennedy et al., 1969). Glyphosate was almost completely destroyed at 800 degrees and largely converted to CO_2. Approximately 5 to 6 percent of the glyphosate was converted to volatile by-products, including primarily acetonitrile, alkylpyridines, and alkylpyrazines. To a lesser extent benzene, toluene, and acetic acid were formed. No information on the combustion of triclopyr is available.

The health risk from potentially toxic pyrolysis products is negligible because the amount of the available parent compound for burning is insignificant after 5 months; and of the material burned, the combustion products of concern would constitute a minute fraction of the total volume of pyrolysis products.

Risk to Workers from Routine Operations

Tables 5-4 to 5-7 summarize the margins of safety for workers based on the systemic and reproductive NOEL's for the 16 herbicides. Full tables showing margins of safety computed for the 16 herbicides are presented in Attachment C, Tables C-1 through C-160. Because of the assumptions that were made to overestimate risk, the Forest Service and BLM estimate that almost all of the operations that take place will fall within the values predicted for the routine-realistic scenarios. Routine-worst case estimates are presented to show the upper bound or 95-percent confidence level of risk to workers.

It must be emphasized that the routine worker exposures and resultant margins of safety are what could be expected in the majority of vegetation management programs in the Pacific Northwest for workers not wearing protective clothing or equipment. All of the studies from which the routine-realistic exposures were calculated are based on workers wearing no protective clothing. The use of protective clothing can substantially reduce worker doses, as shown in field studies of worker exposure, and thereby increase their margins of safety.

Effects of the Use of Protective Clothing

Protective clothing can reduce worker exposures by 27 to 99 percent as shown in a number of relevant field studies. The calculated doses presented below were based on the assumption that workers work with bare hands and wear ordinary work clothing, such as cotton pants and short-sleeve shirts. It is common practice, however, for herbicide applicators to wear clothing that affords more protection. Typical clothing often includes long-sleeve shirts or coveralls, gloves and hats.

Research has shown that such protective clothing can substantially reduce worker exposure. For example, in right-of-way spraying, doses of spray gun applicators wearing clean coveralls and gloves were reduced by 68 percent compared to the doses they got without this protection (Libich et al., 1984) During an aerial spraying operation, mixer/loaders wearing protective clothing reduced their exposure by 27 percent and other crew members reduced their exposure by 58 percent compared to the levels observed without precautions (Lavy et al., 1982).

During insecticide applications to orchards, mixers reduced their exposure by 35 percent and sprayers reduced their exposure by 49 percent by wearing coveralls (Davies et al., 1982). Putnam and coworkers found that nitrofen applicators and mixer/loaders wearing protective clothing reduced their exposure by 94 to 99 percent compared to the doses experienced without protection (Waldron, 1985). Although protective clothing generally does reduce worker exposure and resulting doses, the degree of protection depends on the application system, the work practices, and the specific herbicide. In one extreme case, workers wearing protective clothing did not receive significantly lower doses than workers with less clothing (Lavy et al., 1984). In this case backpack applicators had to treat and move through dense vegetation that was taller than themselves.

Most exposure to herbicide applicators is dermal, not inhalation (Kolmodin-Hedman, et al., 1983), so the use of respirators is ineffective and unnecessary. The hands are the site of the greatest potential herbicide exposure, and rubber gloves are generally quite effective in preventing exposure to hands (Putnam et al., 1983).

Based on the review of field studies protective clothing was normally found to reduce worker doses by the following amounts:

Type of Worker	Percent Reduction in Dose
1. Right-of-way applicators	68.1
2. Aerial application crew members	57.1
3. Aerial mixer/loaders	27.1
4. Injection bar applicators	54.7
5. Hack-and-squirt applicators	57.6

Doses to protected backpack applicators were based on doses to right-of-way applicator who used hand-held nozzles. Tables 5-4 and 5-5 list routine-realistic margins of safety computed for workers without protective clothing and for workers with protective clothing in parentheses. Tables 5-6 and 5-7 list the same values for routine-worst case doses.

Risk to Workers Under Routine-Realistic Scenarios

In the routine-realistic scenario, all categories of workers applying asulam or picloram have MOS's greater than 100. This indicates that even workers chronically exposed to these herbicides should suffer no ill effects. For all the other herbicides, as shown in Tables 5-4 and 5-5, at least one category of worker (primarily backpack sprayers) had MOS's less than 100 in the routine-realistic scenario. This means that unprotected sensitive workers that routinely receive doses this high may experience some toxic effects from applying these herbicides in certain situations.

Backpack sprayers are clearly at greatest risk based on comparisons of estimated doses with systemic and reproductive NOEL's for all of the herbicides. Hand applicators are next, while pilots and mixer-loaders are at somewhat lower risk. Observers and right-of-way applicators are at least risk.

Except for backpack sprayers using asulam or picloram, all backpack sprayers have margins of safety less than 100. Amitrole, atrazine, bromacil, 2,4-D, and triclopyr have MOS's less than 10; and in the case of diuron, the dose exceeds the NOEL. The doses and margins of safety are based on 6 hours per day of exposure. Any reduction in the time of exposure would reduce the dose and increase the margin of safety proportionally.

Diuron appears to be the herbicide presenting the greatest risk from repeated exposures. Backpack sprayers using diuron in the routine-realistic scenario receive a dose that is less than the systemic NOEL. Diuron systemic MOS's for hack-and-squirt applicators are also less than 10 in the routine-realistic case.

2,4-D presents the next highest long-term risk. Backpack sprayers using 2,4-D in the routine-realistic scenarios receive doses that have systemic margins of safety less than 10. Pilots, mixer/loaders, and both types of hand applicators have MOS's less than 50.

Amitrole and triclopyr have at least four margins of safety for workers (including those for backpack sprayers) that are less than 100.

Risk to Workers Under Routine-Worst Case

As shown in Tables 5-6 and 5-7, a number of herbicides have margins of safety less than 10 in the routine-worst case scenario.

Backpack sprayers using diuron, triclopyr, 2,4-D, or amitrole in the routine-worst case scenario receive doses that exceed their respective systemic NOEL's. In addition, doses calculated for truck applicators and hack and squirt applicators using diuron exceed the systemic NOEL. Margins of safety for the reproductive NOEL's are much higher. No applicator dose exceeds the reproductive NOEL for any herbicide in any situation.

All categories of workers, except the aerial supervisor and observer, have margins of safety less than 10 for at least one of the herbicides. Picloram and asulam are the only herbicides that have margins of safety greater than 20 for all categories of workers.

The probability of workers receiving repeated daily doses as high as predicted here is extremely low (less than 1 chance in 1,000). Therefore, even if a worker were to feel ill for a day or so from an unusually high dose, he would not be expected to suffer permanent damage. The vast majority of the time workers will be receiving doses less than those predicted in the routine-realistic scenario. Sensitive individuals would be at greater risk.

The routine-worst case analysis for workers is based on a series of assumptions that, acting together, greatly increase the estimated risk. It uses the upper 2.5 percent of doses received in field studies, the highest application rates used by BLM and the Forest Service, and the longest work hours for each type of project.

If we combine the probability of getting a dose above the upper 95 percent confidence level of field studies (1 in 40), with a probability of using the highest application rate of 1 in 20, and a probability of someone working the maximum hours of 1 in 20, then the probability of a worker getting a dose as high as predicted here is 1 in 16,000. (1/40 x 1/20 x 1/20 = 1/16,000).

Table 5-4
Worker Margins of Safety for Reproductive Effects - Routine-Realistic Scenarios

	Aerial				Back Pack	Truck			Hand Application	
Herbicide	PILOT	MIX/L	SUP	OBS	BP	APPL	MIX/L	APPL MIX/L	H&S	INJ BAR
Amitrole	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)
Asulam	++(++)	720(990)	++(++)	++(++)	250(810)	++(++)	++(++)	++(++)	——	——
Atrazine	++(++)	920(++)	++(++)	++(++)	200(650)	++(++)	++(++)	++(++)	——	——
Bromacil	——	——	——	——	12(38)	580(++)	570(780)	410(790)	71(170)	190(410)
2,4-D	830(++)	580(790)	++(++)	++(++)	130(410)	++(++)	++(++)	++(++)	370(880)	980(++)
2,4-DP	240(580)	170(230)	++(++)	++(++)	30(95)	++(++)	++(++)	810(++)	58(140)	150(340)
Dalapon	++(++)	++(++)	++(++)	++(++)	450(++)	++(++)	++(++)	++(++)	——	——
Dicamba	250(590)	170(240)	++(++)	++(++)	61(190)	++(++)	++(++)	++(++)	45(110)	120(260)
Diuron	——	——	150(330)	——	9.5(30)	460(++)	450(610)		320(620)	56(130)
Fosamine	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)
Glyphosate	250(590)	170(240)	++(++)	++(++)	40(130)	++(++)	++(++)	++(++)	——	——
Hexazinone	++(++)	++(++)	++(++)	++(++)	680(++)	++(++)	++(++)	++(++)	——	——
Picloram	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)	++(++)
Simazine	62(150)	43(59)	410(970)	++(++)	15(49)	730(++)	720(980)	520(++)	——	——
Tebuthiuron	++(++)	++(++)	++(++)	++(++)	360(+)	++(++)	++(++)	++(++)	——	——
Triclopyr	250(590)	170(240)	++(++)	++(++)	30(97)	++(++)	++(++)	++(++)	90(210)	240(520)

Numbers in parentheses refer to margins of safety for workers wearing protective clothing.

MIX/L = Mixer/Loader
SUP = Supervisor
OBS = Observer
BP = Backpack
APPL = Sprayer
H&S = Hack and Squirt
INJ BAR = Injection Bar
++ = MOS of 1000 or more
—— = Not used in respective operation

Table 5-5
Worker Margins of Safety for Systemic Effects - Routine-Realistic Exposures

	Aerial				Back Pack	Truck			Hand Application	
Herbicide	PILOT	MIX/L	SUP	OBS	BP	APPL	MIX/L	APPL MIX/L	H&S	INJ BAR
Amitrole	62(150)	43(59)	410(970)	++(++)	7.6(24)	360(++)	360(490)	260(500)	45(110)	120(260)
Asulam	++(++)	720(990)	++(++)	++(++)	250(810)	++(++)	++(++)	++(++)	——	——
Atrazine	49(120)	34(47)	320(760)	++(++)	7.5(24)	360(++)	350(480)	260(490)	——	——
Bromacil	——	——	——	——	9.5(30)	460(++)	450(610)	320(620)	56(130)	150(330)
2,4-D	33(79)	23(32)	220(520)	++(++)	5.1(16)	190(620)	190(260)	140(270)	15(35)	39(87)
2,4-DP	190(460)	140(190)	++(++)	++(++)	24(76)	910(++)	890(++)	650(++)	47(110)	120(270)
Dalapon	190(440)	130(180)	++(++)	++(++)	23(73)	++(++)	++(++)	780(++)	——	——
Dicamba	++(++)	++(++)	++(++)	++(++)	600(++)	++(++)	++(++)	++(++)	440(++)	++(++)
Diuron	——	——	——	——	-1.1(3.0)	46(150)	45(61)	32(62)	5.6(13)	15(33)
Fosamine	410(990)	290(400)	++(++)	++(++)	51(160)	++(++)	++(++)	++(++)	220(530)	590(++)
Glyphosate	740(++)	520(710)	++(++)	++(++)	120(390)	++(++)	++(++)	++(++)	——	——
Hexazinone	200(470)	140(190)	++(++)	++(++)	54(170)	++(++)	++(++)	830(++)	——	——
Picloram	++(++)	++(++)	++(++)	++(++)	880(++)	++(++)	++(++)	++(++)	++(++)	++(++)
Simazine	62(150)	43(59)	410(970)	++(++)	15(49)	730(++)	720(980)	520(++)	——	——
Tebuthiuron	620(++)	430(590)	++(++)	++(++)	51(160)	++(++)	++(++)	++(++)	——	——
Triclopyr	62(150)	43(59)	410(970)	++(++)	7.6(24)	360(++)	360(490)	260(500)	22(53)	59(130)

Numbers in parentheses refer to margins of safety for workers wearing protective clothing.

MIX/L = Mixer/Loader
SUP = Supervisor
OBS = Observer
BP = Backpack
APPL = Sprayer
H&S = Hack and Squirt
INJ BAR = Injection Bar
++ = MOS of 1000 or more
—— = Not used in respective operation

Table 5-6
Worker Margins of Safety for Reproductive Effects - Routine-Worst Case Scenarios

	Aerial				Back Pack	Truck			Hand Application	
Herbicide	PILOT	MIX/L	SUP	OBS	BP	APPL	MIX/L	APPL MIX/L	H&S	INJ BAR
Amitrole	750(++)	590(600)	++(++)	++(++)	160(520)	++(++)	++(++)	++(++)	790(++)	++(++)
Asulam	89(210)	70(96)	520(++)	++(++)	24(77)	190(600)	330(450)	280(540)	——	——
Atrazine	150(360)	120(160)	860(++)	++(++)	40(130)	220(710)	380(530)	330(630)	——	——
Bromacil	——	——	——	——	——	1.3(4.1)	15(48)	26(36)	22(43)	6.3(15)	23(52)
2,4-D	65(150)	49(67)	360(860)	++(++)	17(54)	190(610)	330(460)	280(550)	33(78)	120(270)
2,4-DP	23(56	)18(25)	130(320)	760(++)	3.7(12)	37(120)	64(88)	55(100)	5.2(12)	19(43)
Dalapon	180(430)	140(190)	++(++)	++(++)	40(130)	570(++)	980(++)	840(++)	——	——
Dicamba	7.5(18)	5.9(8.0)	43(100)	240(580)	2.0(6.5)	26(84)	45(62)	39(75)	4.0(9.3)	15(33)
Diuron	——	——	——	——	1.7(5.4)	7.4(24)	13(18)	11(21)	5.0(12)	19(41)
Fosamine	370(890)	290(400)	++(++)	++(++)	110(340)	++(++)	++(++)	++(++)	590(++)	++(++)
Glyphosate	12(29)	9.4(13)	69(160)	390(120)	3.2(10)	38(120)	65(90)	56(110)	——	——
Hexazinone	250(590)	200(270)	++(++)	++(++)	67(220)	390(++)	680(930)	580(++)	——	——
Picloram	++(++)	980(++)	++(++)	++(++)	420(++)	++(++)	++(++)	++(++)	++(++)	++(++)
Simazine	6.0(14)	4.7(6.4)	34(82)	190(460)	1.8(5.6)	20(66)	36(49)	30(58)	——	——
Tebuthiurom	90(210)	70(96)	520(++)	++(++)	24(78)	370(++)	640(880)	550(++)	——	——
Triclopyr	7.5(18)	5.9(8.0)	43(100)	240(580)	2.0(6.5)	24(76)	41(56)	35(67)	7.9(19)	30(65)

Numbers in parentheses refer to margins of safety for workers wearing protective clothing.
MIX/L = Mixer/Loader
SUP = Supervisor
OBS = Observer
BP = Backpack
APPL = Sprayer
H&S = Hack and Squirt
INJ BAR = Injection Bar
++ = MOS of 1000 or more
—— = Not used in respective operation

Table 5-7
Worker Margins of Safety for Systemic Effects Routine-Worst Case Scenarios

	Aerial				Back Pack	Truck			Hand Application	
Herbicide	PILOT	MIX/L	SUP	OBS	BP	APPL	MIX/L	APPL MIX/L	H&S	INJ BAR
Amitrole	3.7(8.9)	2.9(4.0)	22(51)	120(290)	-1.2(2.6)	5.9(19)	10(14)	8.7(17)	4.0(9.3)	15(13)
Asulam	89(210)	70(96)	520(++)	++(++)	24(77)	190(600)	330(450)	280(540)	——	——
Atrazine	5.5(13)	4.3(5.9)	32(76)	180(430)	1.5(4.8)	8.2(26)	14(20)	12(23)	——	——
Bromacil	——	——	——	——	1.0(3.2)	12(38)	20(28)	17(34)	5.0(12)	19(41)
2,4-D	2.5(5.9)	2.0(2.7)	14(34)	81(190)	-1.5(2.2)	7.7(25)	13(18)	11(11)	1.3(3.1)	4.9(11)
2,4-DP	19(45)	15(20)	110(260)	600(++)	2.9(9.4)	29(94	51(70)	44(84)	4.1(9.7)	15(34)
Dalapon	9.0(21)	7.0(9.6)	52(120)	290(690)	2.0(6.5)	28(91)	49(67)	42(81)	——	——
Dicamba	74(178)	58(80)	440(++)	++(++)	20(64)	28(840)	480(620)	380(740)	40(94)	142(320)
Diuron	——	——	——	——	-5.9(-1.9)	1.4(2.4)	1.3(1.8)	1.1(2.1)	-2.0(1.2)	1.9(4.1)
Fosamine	12(30)	9.8(13)	72(170)	400(960)	3.5(11)	44(140)	76(100)	65(130)	20(47)	74(160)
Glyphosate	36(86)	28(39)	210(490)	++(++)	9.7(31)	110(360)	200(270)	170(320)	——	——
Hexazinone	20(48)	16(21)	110(270)	650(++)	5.4(17)	31(100)	54(75)	47(90)	——	——
Picloram	170(420)	140(190)	++(++)	++(++)	59(190)	++(++)	++(++)	++(++)	230(550)	860(++)
Simazine	6.0(14)	4.7(6.4)	34(82)	190(460)	1.8(5.6)	20(66)	36(49)	30(58)	——	——
Tebuthiuron	12(30)	9.8(13)	72(170)	400(960)	3.4(11)	51(160)	89(120)	76(150)	——	——
Triclopyr	1.9(4.5)	1.5(2.0)	11(26)	60(140)	-2.0(1.6)	5.9(19)	10(14)	8.7(17)	2.0(4.7)	7.4(16)

Numbers in parentheses refer to margins of safety for workers wearing protective clothing.
MIX/L = Mixer/Loader
SUP = Supervisor
OBS = Observer
BP = Backpack
APPL = Sprayer
H&S = Hack and Squirt
INJ BAR = Injection Bar
++ = MOS of 1000 or more
—— = Not used in respective operation

Risk to Workers from Spilling Concentrate or Spray Mix on Their Skin

It must be noted at the outset when considering the effects resulting from these types of accidents that the doses estimated here are based on dermal penetration levels derived in studies over many days; these chemicals do not penetrate the skin immediately but over a considerable period of time. Thus, workers would have to ignore their own safety and not wash the chemical off to receive doses as high as predicted in these accidents.

For workers who spill a pint of concentrate or spray mix on their skin there is a clear possibility that, with the exception of picloram, they could experience some acute toxic effects if they did not wash it off. The margins of safety for this accidental-worst case scenario are presented in Table 5-8. In the case of a spill of a pint of concentrate, many of the doses approach the LD_{50}. This represents a clear risk of severe toxic effects if the chemical is not washed off. There is some possibility that the damage caused by such a large acute dose could cause long-term damage to vital organs. There have also been rare instances in which limited exposure to 2,4-D caused permanent nerve damage. The dose and the risk are much greater for spills of concentrate than for the spray mix but, again, it is highly unlikely a worker would allow the chemical to penetrate his skin for any length of time. Attachment C presents the complete MOS and comparisons to LD_{50}'s for each herbicide.

Table 5-8
Margins of Safety for Spills onto the Skin of Workers Compared to Systemic NOEL's and LD_{50}'s

	Spray Mix		Concentrate	
Herbicide	NOEL	LD_{50}	NOEL	LD_{50}
Amitrole	-9.6	17,000	-48	3,400
Asulam	2.5	200	-4.8	17
Atrazine	-6.5	78	-65	7.8
Bromacil	-1.9	330	-38	17
2,4-D	-14	26	-140	2.6
2,4-DP	-1.9	55	-46	2.3
Dalapon	-4.0	130	--	--
Dicamba	-9.6	63	-96	6.3
Diuron	-31	200	-380	16
Fosamine	-2.9	340	-9.6	100
Glyphosate	-1.0	140	-6.0	24
Hexazinone	-1.8	94	-12	14
Picloram	4.9	5,700	1.2	1,400
Simazine	-6.0	170	-48	21
Tebuthiuron	-2.9	18	--	--
Triclopyr	-19	13	-96	2.6

Risk to Workers and the Public from Accidents Causing Large Spills of Herbicide

Table 5-9 summarizes the margins-of-safety for people drinking one quart of water contaminated by a large spill of herbicide from a helicopter or truck (see Attachment C, Tables C-145 through C-160). Most drinking water reservoirs would dilute the herbicide below no-observable-effect levels in a relatively short period of time. Both BLM and the Forest Service, in addition to EPA and the states, have procedures to minimize the risk to human health should a spill of this magnitude occur in or near a drinking water reservoir. Therefore, after the spill has been diluted, the risk to members of the public can be considered very low.

Spills into a small, stagnant pond would result in significantly higher doses and, in the event of a truck spill of 1,000 gallons would constitute a risk of chronic effects if members of the public continued to drink from it. Both the Forest Service and BLM have detailed spill prevention and clean up procedures to ensure that no member of the public is chronically exposed to a spill of this magnitude.

Probability of a Worst Case Accident

Some indication of the likelihood of significant her-

Table 5-9
Margins of Safety for People Drinking One Quart of Water Contaminiated by a Large Spill of Herbicide[a] Compared to the Systemic NOEL

	Helicopter		Truck	
Herbicide	Into a Reservoir	Into a Pond	Into a Reservoir	Into a Pond
Amitrole	11	-2.9	1.1	-29
Asulam	26,000	810	2,600	81
Atrazine	1600	50	160	5.0
Bromacil	--	--	540	17
2,4-D	430	14	43	1.4
2,4-DP	3,500	110	350	11
Dalapon	2,600	81	260	8.1
Dicamba	540	17	54	1.7
Diuron	--	--	34	1.1
Fosamine	3,600	110	360	11
Glyphosate	10,000	330	1,000	33
Hexazinone	5,800	180	580	18
Picloram	2,400	76	240	7.6
Simazine	1,700	54	170	5.4
Tebuthiuron	3,600	110	360	11
Triclopyr	540	17	54	1.7

[a]Assume a helicopter carrying 100 gallons of spray mix jettisons the entire load in a 16-acre by 8-foot-deep reservoir and a 1-acre by 4-foot-deep pond.

bicide spill accidents occurring may be derived from historical data. Herbicide spill accidents recorded by BLM and the Forest Service over 11 years were classified by location, date, and quantity spilled. Also included was information specifying the occurrence of accidents on the ground or in the air, and if the spill was near a waterway. Over an 11-year period, from 1973 through 1983, there were 24 recorded spills averaging 44.4 gallons per accident. Herbicide use rates ranged from 1.5 lb a.i. to 7 lb a.i. per acre for normal use rates. For a total of 302,085 acres sprayed during the 11-year period there was one accident for every 12,587 acres and 54 percent of the spills involved 30 gallons or less.

Table 5-10 shows the acreage sprayed, gallons spilled, and type of spill for the years 1973 to 1983. Figures 5-1 and 5-2 show that as the number of gallons increases, the probability of a spill decreases.

Cancer Risk

A worst-case analysis for cancer was conducted for the herbicides that had positive laboratory oncogenic studies (amitrole, asulam, bromacil, and 2,4-DP) and for the herbicides (2,4-D, glyphosate, and picloram) for which there is scientific uncertainty. There is no evidence to suggest that any of the other herbicides could cause cancer. All of the other herbicides have negative cancer studies. EPA has requested additional data on the cancer potential of a number of the other 11 herbicides, and BLM and the Forest Service will consider the results of their findings when they become available.

Cancer is generally thought of as a nonthreshold response, which means a very small amount could cause a tumor and there is general agreement that amitrole has the potential to cause cancer in humans. In the case of amitrole, however, EPA has determined that the available evidence indicates a threshold carcinogenic response. A threshold response is consistent with the theory that amitrole is a secondary carcinogen because of its well-established anti-thyroid effects. Nevertheless, because there is some uncertainty about the mechanism of action of amitrole, a conservative approach has been taken in this analysis by assuming that amitrole's carcinogenicity is not a threshold effect. A threshold model would indicate zero or negligible carcinogenicity at low doses. This would be true of the log-probit model suggested by EPA (EPA, 1984s), but instead, the one-hit model has been used here under the assumption that even low doses may cause cancer. The one-hit model used for estimating the risk for all herbicides in this analysis predicts the maximum rates of cancer that could occur at low doses under any of the models that have been in general use. At high doses, all of the commonly used models would predict nearly the same rate of tumor formation.

Table 5-10
Number of Spills on Forest Service Land in Washington and Oregon over the Last 10 Years

Number of Gallons	Number Spills (air and ground)	Avg. No. of Spills/ 1,000 Acres	Number Spills (air)	Avg. No. of Spills/ 1,000 Acres
0	24	0.0795	9	0.0298
10	19	0.0629	9	0.0298
20	14	0.0464	6	0.0199
30	11	0.0364	5	0.0166
40	11	0.0364	5	0.0166
50	10	0.0331	4	0.0132
60	8	0.0265	4	0.0132
70	6	0.0199	2	0.0066
80	6	0.0199	2	0.0066
90	3	0.0099	2	0.0066
100	1	0.0033	0	0.0000

Cancer risks for amitrole, asulam, bromacil, 2,4-DP, 2,4-D, glyphosate, and picloram have been calculated based on a variety of conservative assumptions that are likely to overestimate the risks. These assumptions include the following:

1. Amitrole, asulam, bromacil, 2,4-DP, glyphosate, picloram, and 2,4-D are all assumed to be carcinogenic. Picloram and 2,4-D have not been shown conclusively to be carcinogenic in laboratory tests and there are many uncertainties about the glyphosate study, but the evidence also cannot show conclusively that they are not carcinogenic. Consequently, a worst case approach was taken.

2. In cases where there is more than one data set available, the data set indicating greater carcinogenic potency has been chosen. Carcinogenic potencies of 2,4-D and 2,4-DP have been calculated based on the rate of tumor formation in the female Osborne-Mendel rats studied by Hansen et al. (1971). This is the species and sex that have exhibited the highest rate of tumor formation after 2,4-D administration. All tumors were considered, although many of them were benign. Similarly for amitrole, the Food and Drug Research Laboratories rat study data (discussed in section 3) have been used.

3. It is assumed that carcinogenicity in all seven cases is not a threshold phenomenon: i.e., any dose of these chemicals has some probability of causing cancer, no matter how small the dose. This assumption is questionable for amitrole;

EPA has determined that the evidence suggests a threshold phenomenon in this case.

4. The one-hit model was used to represent the relationship between dose and rate of tumor formation. This is the most conservative of several models that have been proposed because it predicts the highest cancer rates at the relatively low doses predicted for exposed humans. Other models that could have been used include the multistage, multihit, Weibull, logit, and probit models. The choice of model can affect the predicted cancer rates over several orders of magnitude. The one-hit model was used at one time by EPA, but the less conservative multistage model is now normally used. In the case of amitrole, EPA has suggested use of the even less conservative log-probit model.

5. In each case a 95-percent upper confidence limit was used to estimate cancer potency. For asulam, bromacil, 2,4-D and picloram these potencies were estimated using the maximum-likelihood procedure of the GLOBAL 82 computer program (Howe and Crump, 1982).

6. Interspecies extrapolation is a major source of uncertainty in judging cancer risk. The scaling method used in this analysis is the most conservative of the commonly accepted methods. The cancer potency of each chemical for humans was assumed to be the same as the potency for rats when scaled in terms of mg per m^2 of body surface area (mg/m^2). This method is commonly used by EPA and others, but it is not the only acceptable approach. Another equally acceptable (OSTP, 1985) method is to scale doses in terms of mg per kg of body weight (mg/kg), resulting in estimates of cancer risk that are about 16 percent of those calculated here.

7. The range of doses calculated for workers and the public in the basic scenarios covers even extreme exposures that might be encountered with each application method. Unusual exposure situations, represented by accidental spraying and large herbicide spills, have also been considered.

The probability of occurrence of cancer over a lifetime as a result of exposure to each of the chemicals was calculated using the following equations:

$$P(d) = 1 - \exp(-K \times b \times d)$$

$$d = D \times N/L$$

where:

P(d) is a conservative estimate of the probability of cancer during a person's lifetime as the result of dose d.

d is the average daily dose over a lifetime (mg/kg/day)

K is an interspecies extrapolation factor

b is a conservative estimate for cancer potency in the test animal (derived in section 2).

The following cancer potencies (per mg/kg/day) were used: amitrole, 1.4; 2,4-DP, 5.9×10^{-2}; asulam, 2×10^{-2}; 2,4-D, 5.0×10^{-3}; bromacil, 3.8×10^{-3}; picloram, 5.7×10^{-4}; and glyphosate, 2.4×10^{-5}.

D is the daily dose (mg/kg/day)

N is the number of days during which the dose D occurs during an individual's lifetime

L is the number of days in a lifetime, taken to be 25,550 for a 70-year lifespan.

The interspecies extrapolation factor, K, can be estimated by assuming that body surface area is proportional to body weight to the 2/3 power (Mantel and Schneiderman, 1975), so that K would be:

$$K = (\text{human weight/test animal weight})\ 1/3$$

For an average human weight of 50 kg and an average rat weight of 350 g, K is estimated to be 5.2.

Cancer Risk to the Public

Cancer risk for the general public has been calculated for a single exposure, and also for 30 exposures over a lifetime. The approximate cancer risks to the public for the routine-realistic and routine-worst case aerial scenarios are shown in Tables 5-11 and 5-12. (See Attachment C for the presentation of cancer risks to the public for the other four routine exposure scenarios.) Of the seven chemicals, the greatest risks are shown for amitrole. In the highest exposure situation, the large aerial scenario, the maximum risk of cancer for a single exposure is less than 6 in 1 million, for a person eating vegetables from near the spray site. Even when several routes of exposure are added for the example nearby resident, the resulting risk for a single incident is still less than 10 in 1 million. The cumulative risk due to several exposures of this magnitude would be the sum of the risks for each exposure. The risk of cancer

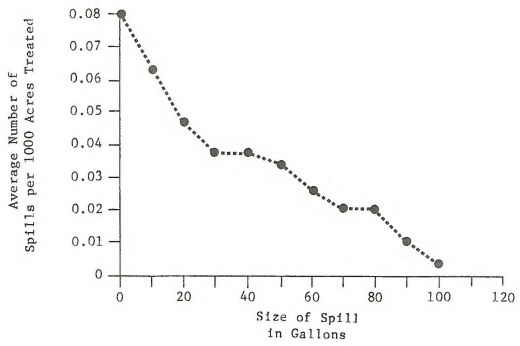


Figure 5-1 Frequency and Size of Spills from Air and Ground Operations

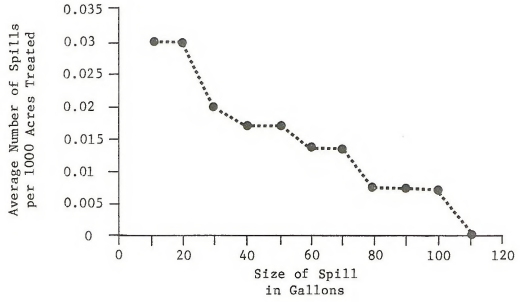


Figure 5-2 Frequency and Size of Spills from Air Operations

from 30 exposures is also given in the tables, but the chance of receiving 30 exposures as large as those in the worst case is negligible. If 30 routine-worst case exposures were experienced, the cumulative risk would be less than 3 in 10,000. Exposures in the routine-realistic cases lead to much lower risk. The risk of cancer due to doses from any of the routes of exposure in the typical aerial spraying scenario is less than 2 in 100,000, even for amitrole. Cancer risks for the other chemicals are very much less. The risk for glyphosate is never greater than 2 in 1 billion. For 2,4-D, 2,4-DP, asulam, and picloram, none of the routes of exposure in any scenario results in a cancer risk greater than about 2 in 10 million, per exposure. The highest risk of cancer to the public from bromacil usage is from backpack spraying of large areas because bromacil is not aerially applied in the forests of Region 6. The risk due to any routes of exposure is less than 4 in 100 million (Table C-162).

Cancer Risk to Workers

Cancer risk to workers has been calculated for an expected case assuming 5 years of employment in

Table 5-11
Lifetime Cancer Risk--Exposed Public Realistic Aerial, 40 Acres by Helicopter

Routes of Exposure	Exposures per Lifetime	Risk from Exclusive Use of:						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal,Spray Vegetation Contact	1	10^{-11}	10^{-10}	10^{-12}	--[a]	10^{-14}	10^{-11}	10^{-13}
Hiker	1	10^{-13}	10^{-12}	10^{-14}	--	10^{-15}	10^{-13}	10^{-15}
Picker	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-12}	10^{-9}	10^{-11}
Drinking Water	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-7}	10^{-11}
Eating Berries	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-11}	10^{-7}	10^{-11}
Eating Vegets.	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-7}	10^{-11}
Eating Deer	1	10^{-10}	10^{-9}	10^{-11}	--	10^{-12}	10^{-8}	10^{-12}
Eating Fish	1	10^{-10}	10^{-9}	10^{-10}	--	10^{-11}	10^{-7}	10^{-12}
Combined Routes of Exposure								
Hiker	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-7}	10^{-11}
Berry Picker	1	10^{-9}	10^{-8}	10^{-9}	--	10^{-10}	10^{-7}	10^{-11}
Hunter	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-7}	10^{-11}
Fisherman	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-7}	10^{-11}
Resident	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-6}	10^{-11}
For 30 Exposures								
Dermal, Spray Vegetation Contact	30	10^{-10}	10^{-9}	10^{-10}	--	10^{-12}	10^{-9}	10^{-12}
Hiker	30	10^{-12}	10^{-11}	10^{-12}	--	10^{-14}	10^{-11}	10^{-14}
Picker	30	10^{-8}	10^{-7}	10^{-8}	--	10^{-10}	10^{-7}	10^{-9}
Drinking Water	30	10^{-8}	10^{-7}	10^{-8}	--	10^{-9}	10^{-5}	10^{-10}
Eating Berries	30	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Eating Vegets.	30	10^{-8}	10^{-7}	10^{-8}	--	10^{-9}	10^{-5}	10^{-10}
Eating Deer	30	10^{-9}	10^{-8}	10^{-9}	--	10^{-10}	10^{-6}	10^{-11}
Eating Fish	30	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Combined Routes of Exposure								
Hiker	30	10^{-8}	10^{-7}	10^{-8}	--	10^{-9}	10^{-5}	10^{-10}
Berry Picker	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-9}	10^{-5}	10^{-9}
Hunter	30	10^{-8}	10^{-7}	10^{-8}	--	10^{-9}	10^{-5}	10^{-10}
Fisherman	30	10^{-7}	10^{-7}	10^{-8}	--	10^{-9}	10^{-5}	10^{-10}
Resident	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-9}	10^{-5}	10^{-9}

[a]Not used in aerial application.

Table 5-12
Lifetime Cancer Risk--Exposed Public Large Aerial, 400 Acres by Fixed Wing, Worst Case

Routes of Exposure	Exposures per Lifetime	Risk from Exclusive Use of: 2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray Vegetation Contact	1	10^{-8}	10^{-8}	10^{-9}	--[a]	10^{-10}	10^{-8}	10^{-10}
Hiker	1	10^{-10}	10^{-9}	10^{-11}	--	10^{-12}	10^{-10}	10^{-12}
Picker	1	10^{-8}	10^{-7}	10^{-9}	--	10^{-10}	10^{-7}	10^{-10}
Drinking Water	1	10^{-8}	10^{-8}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Eating Berries	1	10^{-8}	10^{-8}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Eating Vegets.	1	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Eating Deer	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-7}	10^{-11}
Eating Fish	1	10^{-9}	10^{-8}	10^{-10}	--	10^{-10}	10^{-6}	10^{-11}
Combined Routes of Exposure								
Hiker	1	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Berry Picker	1	10^{-8}	10^{-7}	10^{-8}	--	10^{-9}	10^{-6}	10^{-9}
Hunter	1	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Fisherman	1	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
Resident	1	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-6}	10^{-10}
For 30 Exposures								
Dermal, Spray Vegetation Contact	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-9}	10^{-6}	10^{-9}
Hiker	30	10^{-9}	10^{-8}	10^{-9}	--	10^{-11}	10^{-8}	10^{-10}
Picker	30	10^{-7}	10^{-6}	10^{-7}	--	10^{-9}	10^{-6}	10^{-8}
Drinking Water	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-8}	10^{-4}	10^{-9}
Eating Berries	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-8}	10^{-5}	10^{-9}
Eating Vegets.	30	10^{-7}	10^{-6}	10^{-7}	--	10^{-8}	10^{-4}	10^{-9}
Eating Deer	30	10^{-8}	10^{-7}	10^{-9}	--	10^{-9}	10^{-5}	10^{-10}
Eating Fish	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-8}	10^{-5}	10^{-9}
Combined Routes of Exposure								
Hiker	30	10^{-7}	10^{-6}	10^{-7}	--	10^{-8}	10^{-4}	10^{-8}
Berry Picker	30	10^{-6}	10^{-5}	10^{-7}	--	10^{-7}	10^{-4}	10^{-8}
Hunter	30	10^{-7}	10^{-6}	10^{-7}	--	10^{-8}	10^{-4}	10^{-8}
Fisherman	30	10^{-7}	10^{-6}	10^{-7}	--	10^{-8}	10^{-4}	10^{-8}
Resident	30	10^{-6}	10^{-5}	10^{-7}	--	10^{-7}	10^{-4}	10^{-8}

[a]Not used in aerial application.

herbicide application, and an average number of days of spraying per year. The average number of exposures per lifetime was estimated to range from 30 to 70. The risk has been calculated in the extreme cases assuming 30 years of employment and a total of 288 to 480 exposures. It is very unlikely that a worker would apply herbicides on the number of days assumed in the worst case. The lifetime cancer risks for workers are shown in Table 5-13. (Cancer risk to workers for the accidental-worst case scenario is shown in Attachment C.) The risks for each herbicide were calculated assuming that only that herbicide was used. The highest risks for workers involve 2,4-DP use. The lifetime cancer risk to a backpack sprayer using only 2,4-DP is about 2 in 10,000 in the expected case. In the worst case the risk is greater than 1 in 1,000. The risk is much less for the other chemicals. The highest risk for 2,4-D is about 1 in 100,000 for backpack spraying in the expected case, and in the extreme case the greatest risk is about 1 in 10,000. The risk is somewhat greater for amitrole: as high as 7 in 100,000 for the realistic backpack exposure. Workers using asulam and

bromacil in the extreme case have a lifetime cancer risk of less than 6 in 100,000 in all worker categories. The cancer risk from picloram or glyphosate use is even less for all worker categories. The risk in the expected case never exceeds 3 in 10 million.

EPA (1985a) has also conducted a carcinogenic risk assessment for workers using amitrole (see Table 5-14). EPA assumed that workers wore no protective clothing, and the estimated exposures were only 1.5×10^{-3} mg/kg/day for the highest exposures. EPA estimated cancer potency for both liver and thyroid tumors, using the log-probit and multistage models. Estimated cancer risks for the anti-thyroid action of amitrole were all less than 1 in 10 billion based on the log-probit model. The multistage model gave much higher risk estimates, especially for liver tumors. Calculated risks for average worker exposures were not greater than 1 in 10,000, and for maximum exposures the risks were not greater than 1 in 1,000. Amitrole carcinogenicity risks calculated in this risk assessment are consistent with EPA's independently derived results.

Cancer Risks in Accidental Situations

Cancer risks calculated for exposures due to accidental spraying are shown in Attachment C (Table C-165). The greatest risks among the seven chemicals are for amitrole. A single incident of accidental spraying of amitrole gives calculated risks of 6 in 100,000 for a person eating sprayed vegetables and 3 in 100,000 for a person drinking sprayed water. Among the other chemicals, the greatest risks are about 4 in 1 million for exposures to 2,4-DP, and 3 in 10 million for 2,4-D. Multiple incidents could be expected to result in cumulative

Table 5-13
Lifetime Cancer Risk - Exposed Workers

Worker Category	Exposures per Lifetime	Risk from Exclusive Use of: 2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For Realistic Number of Exposures								
Pilot	30	10^{-6}	10^{-5}	10^{-7}	--[a]	10^{-8}	10^{-5}	10^{-8}
Mixer-Loader	30	10^{-6}	10^{-5}	10^{-7}	--	10^{-8}	10^{-6}	10^{-8}
Supervisor	30	10^{-7}	10^{-6}	10^{-8}	--	10^{-9}	10^{-7}	10^{-9}
Observer	30	10^{-8}	10^{-7}	10^{-8}	--	10^{-10}	10^{-7}	10^{-10}
Backpack	50	10^{-5}	10^{-4}	10^{-6}	10^{-6}	10^{-8}	10^{-5}	10^{-7}
R-O-W Sprayer	45	10^{-7}	10^{-6}	10^{-7}	10^{-7}	10^{-9}	10^{-6}	10^{-8}
R-O-W Mix/L	45	10^{-7}	10^{-6}	10^{-7}	10^{-7}	10^{-9}	10^{-6}	10^{-9}
R-O-W AP/M/L	45	10^{-7}	10^{-6}	10^{-7}	10^{-7}	10^{-9}	10^{-6}	10^{-9}
Hack and Squirt	70	10^{-6}	10^{-4}	--[b]	10^{-6}	10^{-8}	10^{-5}	--
Injection Bar	70	10^{-6}	10^{-5}	--	10^{-7}	10^{-8}	10^{-6}	--
Worst Case Number of Exposures								
Pilot	288	10^{-5}	10^{-4}	10^{-6}	--	10^{-8}	10^{-5}	10^{-7}
Mixer-Loader	288	10^{-5}	10^{-4}	10^{-6}	--	10^{-7}	10^{-5}	10^{-7}
Supervisor	288	10^{-6}	10^{-5}	10^{-7}	--	10^{-8}	10^{-6}	10^{-8}
Observer	288	10^{-7}	10^{-6}	10^{-7}	--	10^{-9}	10^{-6}	10^{-9}
Backpack	440	10^{-4}	10^{-3}	10^{-5}	10^{-5}	10^{-7}	10^{-4}	10^{-6}
R-O-W Sprayer	416	10^{-6}	10^{-5}	10^{-6}	10^{-6}	10^{-8}	10^{-5}	10^{-8}
R-O-W Mix/L	416	10^{-6}	10^{-5}	10^{-6}	10^{-6}	10^{-8}	10^{-5}	10^{-8}
R-O-W AP/M/L	416	10^{-6}	10^{-5}	10^{-6}	10^{-6}	10^{-8}	10^{-5}	10^{-8}
Hack and Squirt	480	10^{-5}	10^{-4}	--	10^{-5}	10^{-7}	10^{-4}	--
Injection Bar	480	10^{-5}	10^{-4}	--	10^{-6}	10^{-8}	10^{-5}	--

[a]Not used in aerial application.
[b]Not used in hand application.

Table 5-14
Amitrole Worker Exposure Estimates and Related Estimates of Cancer Risk

Exposure Situation[a]	Exposure (mg/kg/day)	Log-Probit[b]	Upper 95% Bound on Risk Multi-Stage	
			Q_{1e}^* = .20[c]	Q_{1u}^* = .076[d]
Utility Power Wagon Mixer-Loader/Applicator				
Minimum	$1.1x10^{-4}$	10^{-10}	10^{-5}	10^{-5}
Average	$4.6x10^{-4}$	10^{-10}	10^{-4}	10^{-5} - 10^{-4}
Maximum	$1.2x10^{-3}$	10^{-10}	10^{-4}	10^{-4}
Industry Power Wagon Mixer/Loader/Applicator				
Mininum	$6.3x10^{-5}$	10^{-10}	10^{-51}	10^{-6} - 10^{-5}
Average	$4.3x10^{-4}$	10^{-10}	10^{-4}	10^{-5} - 10^{-4}
Maximum	$1.1x10^{-3}$	10^{-10}	10^{-4}	10^{-4}
Industry Knapsack/ Hand Carry Applicator				
Minimum	$4.9x10^{-6}$	10^{-10}	10^{-6}	10^{-7} - 10^{-6}
Average	$3.7x10^{-4}$	10^{-10}	10^{-5} - 10^{-4}	10^{-5}
Maximum	$1.5x10^{-3}$	10^{-10}	10^{-4} - 10^{-3}	10^{-4}
Industry Knapsack/ Hand Carry/Mixer-Loader				
Minimum	$5.3x10^{-7}$	10^{-10}	10^{-7}	10^{-8} - 10^{-7}
Average	$2.7x10^{-4}$	10^{-10}	10^{-6} - 10^{-5}	10^{-6}
Maximum	$1.3x10^{-4}$	10^{-10}	10^{-5}	10^{-5}

[a]Exposure estimates of dermal exposure and inhalation exposure were taken from Hitch memo of 12/15/83 adjusted for a maximum of 0.1 percent dermal penetration. Zendzian memo of 6/26/85, annual exposure estimate is divided by 70kg to obtain exposure in mg/kg and by 365 and 2 to obtain average daily dose for one-half of a 70-year lifetime.

[b]Log-Probit: This column represents the risk bounds under the assumption of the anti-thyroid action of amitrole.

[c]Q_{1e}^*: This column represents the rick bounds under the assumption of the interspecies surface area correction; and based on liver tumors in female mice.

[d]Q_{1u}^*: This column represents the risk bounds without the interspecies surface area correction; and based on thyroid tumors in male rats.

risks. Cancer risks calculated for spill situations are also shown in Attachment C. The greatest risks are for spills of herbicide concentrate directly onto clothing and skin. Workers are at the greatest risk for this type of accident. The tabled values assume that most of a person's skin has been contacted by the solution, and cleanup does not occur for several hours. This is certainly contrary to standard practice. A spill of 2,4-DP concentrate onto a person gives a risk of about 3 in 1,000, and a spill of spray mixture gives a lesser risk of about 1 in 10,000. The corresponding risks for 2,4-D and amitrole are about a factor of 10 less. The risk of cancer due to spills of asulam and bromacil is about 1 in 100,000 for the concentrate and 1 in 1 million for the spray mixture. A spill of picloram or glyphosate concentrate gives a risk of 2 in 1 million or less. Cancer risks arising from even major spills into drinking water supplies are significantly less. A 100-gallon helicopter load of amitrole spray mixture dumped into a 1-acre pond would lead to a risk of cancer of not more than 2 in 100,000 for a person drinking a liter of the water. The corresponding risks for the other chemicals are very much less. If a 1,000-gallon tank truck of spray mixture were spilled into a small pond, the risk for amitrole would be about 2 in 10,000. For 2,4-D the corresponding cancer risk is less than 1 in 1 million.

Comparison of Cancer Risks with Other Common Risks

To put the cancer risks calculated here in perspective, Table 5-15 lists risks due to some more familiar hazards and occupational risks. Motor vehicle accidents have a risk of fatality that averages 2 in 10,000 per person each year. Over a 30-year period, the cumulative risk would be 6 in 1,000. A variety of hazards are listed in the table that have a risk of about 1 in 1 million. They include smoking 2 cigarettes, eating 6 pounds of peanut butter, drinking 40 sodas sweetened with saccharin, or taking one transcontinental round trip by air. The cancer risk for a single x ray is 7 in 1 million. Many oc-

Table 5-15
Lifetime Risk of Death or Cancer Resulting from Everyday Activities

Activity	Need to Accumulate a One in a Million Risk of Death	Average Annual Risk [a] per Capita
Based on living in the United States		
Motor vehicle accident	1.5 days	2×10^{-4}
Falls	6 days	6×10^{-5}
Drowning	10 days	4×10^{-5}
Fires	13 days	3×10^{-5}
Firearms	36 days	1×10^{-5}
Electrocution	2 months	5×10^{-6}
Tornados	20 months	6×10^{-7}
Floods	20 months	6×10^{-7}
Lightning	2 years	5×10^{-7}
Animal bite or sting	4 years	2×10^{-7}
Occupational Risks		
General		
manufacturing	4.5 days	
	8×10^{-5}	
trade	7 days	5×10^{-5}
service and government	3.5 days	1×10^{-4}
transport and public utilities	1 day	4×10^{-4}
agriculture	15 hours	6×10^{-4}
construction	14 hours	6×10^{-14}
mining and quarrying	9 hours	1×10^{-3}
Specific		
coal mining (accidents)	14 hours	6×10^{-4}
police duty	1.5 days	2×10^{-4}
railroad employment	1.5 days	2×10^{-4}
fire fighting	11 days	8×10^{-4}
Everyday Risks		
Eating and drinking	40 diet sodas (saccharin) 6 pounds of peanut butter (aflatoxin) 180 pints of milk (aflatoxin) 200 gallons of drinking water from Miami or New Orleans 90 pounds of broiled steak (cancer risk only)	
Smoking	2 cigarettes	

[a]Note to calculate the risk over a lifetime multiply this column by 70. From Crouch and Wilson (1982).

cupational risks are greater. Working for 30 years in agriculture or construction has a risk of about 1.8 in 100, and in mining and quarrying the risk is even greater: 3 in 100 over 30 years.

Risk of Heritable Mutations

No human studies are available that associate any of the herbicides with heritable mutations. Furthermore, no risk assessments that quantify the probability of mutations are available in the literature or from EPA. Laboratory studies constitute the best

available information on mutagenic potential. Results of the mutagenicity assays conducted on the 16 herbicides are summarized in Table 3-3.

For some of the herbicides, no validated mutagenicity tests exist or the mutagenicity tests conducted are insufficient to conclude whether the chemical is mutagenic. For these herbicides, a worst case assumption is made that these herbicides have the potential to cause mutations in humans. In these cases the results of carcinogenicity tests (see Table 3-3) or cancer risk assessments can be used to estimate the risk of heritable mutations. The rationale for this assumption is summarized by the USDA (1985) as follows: "Since mutagenicity and carcinogenicity both follow similar mechanistic steps (at least those that involve genetic toxicity), the increased risk of cancer can be used to approximate the quantitative risk of heritable mutations. The basis for this assumption is that both mutagenicity and at least primary carcinogens react with DNA to form a mutation or DNA lesion affecting a particular gene or set of genes. The genetic lesions then require specific metabolic processes to occur, or the cells must divide to insert the lesion into the genetic code of the cell. We believe the cancer risk provides a worst case approximation to heritable mutations because cancer involves many types of cells whereas heritable mutations involve only germinal (reproductive) cells."

Asulam and glyphosate tested negative for mutagenicity in all assays conducted, and thus can be considered to pose no mutagenic risk.

Fosamine, hexazinone, simazine, and triclopyr were nonmutagenic in the great majority of assays conducted and were nononcogenic in all of the carcinogenicity tests performed; therefore, it can be assumed that their mutagenic risk is slight to negligible. Dicamba was nonmutagenic in most of the assays performed and no oncogenicity was found in several long-term studies. EPA (1985d) has classified the chronic studies as "inadequate to evaluate the oncogenic potential of dicamba." Due to the bulk of negative results, dicamba can be considered as a mutagen in the worst case analysis but the mutagenic hazard would be extremely limited.

No validated mutagenicity studies have been conducted with bromacil, dalapon, or diuron. The worst case assumption is that all of these chemicals are mutagenic. The probability of dalapon or diuron causing heritable mutations is low because they have not been shown to cause cancer in any long-term studies.

The negative oncogenic studies for diuron were classified by EPA (1985d) as inadequate to determine carcinogenic potential to mammalian organisms. The lack of positive results in mutagenic or oncogenic tests with diuron suggests that diuron would present a very low risk to humans as a mutagen.

Bromacil tested positive in one of two oncogenic studies. The risk of heritable mutations from the chemical should be no greater than the estimates of cancer risk based on a worst case approximation.

Atrazine tested positive for mutagenicity in 15 of 33 assays. The worst case assumption is that atrazine is mutagenic. However, many of the positive results were achieved through tests that may not be relevant to evaluating mutagenic risk in humans. Some positive results in rodents were also achieved, but these in vivo responses were only observed at levels greater than 1,500 mg/kg body weight. These are exceptionally high levels and suggest that the degree of germ cell hazard from low levels of atrazine would be minimal.

Amitrole was nonmutagenic in 56 microbial gene mutation tests. The results of two tests which were positive are considered of questionable validity by EPA (1985a), and overall it is considered to pose no potential for heritable mutations (EPA, 1985a). The worst-case estimate for amitrole mutagenic effects would be the risk of cancer as shown in Tables 5-11 and 5-12.

For picloram and 2,4-D, there have been only a few studies performed and these have indicated both positive and negative mutagenic potential. EPA has requested more mutagenicity-test information for both of these compounds. A number of comprehensive reviews of the 2,4-D mutagenic data have indicated that it does not pose significant risk of human gene mutations (USDA, 1984). 2,4-D has been shown to be nononcogenic in the two carcinogenicity studies that have been conducted. Based on a worst case estimate, the risk of heritable mutations from these chemicals would be no greater than the estimates of cancer risk.

Mutagenic tests with 2,4-DP have shown mixed results. 2,4-DP was negative in four microbial assays and positive in four other assays; therefore it may have limited genotoxic potential. Based on the limited test data presented in Section 3, one cannot presume mutagenic hazard because no in vivo or mammalian assays have been conducted. However, the worst case assumption is that 2,4-DP is mutagenic and the mutagenic risk in the worst case would be no greater than the risk of cancer.

Synergistic and Cumulative Effects

Synergistic Effects

Synergistic effects of herbicides are those that occur because of simultaneous exposure to more than one herbicide and that cannot be predicted based on the effects of the individual chemicals. A synergistic effect occurs when the combined effect of two chemicals is much greater than the sum of the effects of each agent given alone. Based on the limited amount of data available on pesticide combinations, it is possible but very unlikely that synergistic effects could occur as a result of exposure to two or more of the herbicides considered in this analysis.

The effects of many of the possible herbicide combinations have not been studied. This is not surprising because the first priority must be to study the effects of the herbicides individually, and this type of information is not yet sufficient in some cases. Moreover, the combinations that could be studied are too numerous to be listed. The combinations of interest include not only combinations of 2 or more of the 16 herbicides, but also combinations of the herbicides with other chemicals, such as insecticides, that exist in the environment.

However, Kociba and Mullison (1985) in describing toxicological interactions with agricultural chemicals state:

> Our present scientific knowledge in toxicology indicates than an exposure to a mixture of pesticides is more likely to lead to additivity or antagonism rather than synergism when considering the toxicological effects of such a combination. To be conservative and for reasons of safety, an additive type of toxicological response is generally assumed rather than an antagonistic type of response.
>
> In the case of registered pesticides, a great amount of toxicological information is developed during the research and development of each individual pesticide. In addition to this information on individual pesticides, short term toxicity studies are always done prior to the selling of a pesticide mixture. Should synergism unexpectedly be present in a proposed commercial mixture of two pesticides, it would be identified in such cases and would then be dealt with accordingly. In toxicological tests involving a combination of commercial pesticides, synergism has generally not been observed.

Kociba and Mullison (1985) use a specific example of a mixture of 2,4-D and picloram to illustrate their point. They list the LD_{50}'s of each herbicide separately and the $LD_{50}$of the mixture. The mixture $LD_{50}$is between the LD_{50}'s of the two constituents indicating lack of a synergistic effect.

The possibility of synergistic effects can be examined for the 16 herbicides addressed in this analysis in the same way. Based on a review of acute LD_{50}'s for mixtures of 2 or more of the 16 herbicides used in this analysis that have been submitted to EPA, no synergistic effects were found.

In no case is the mixture of two herbicides more acutely toxic than any of the constituents. This gives at least a first indication that synergistic effects are unlikely to occur in the vegetation management program.

Moreover, it is highly unlikely that synergistic adverse effects could result from exposure to more than one herbicide applied in separate projects. There are several reasons for this. First, unlike the situation in conventional agriculture, herbicide residues in plants and soil are not expected to persist from one application to another, even for the more persistent herbicides. Silvicultural and range applications are not annual; there are typically many years between applications.

Second, none of the 16 herbicides accumulates in human tissues, so exposure of an individual to 2 herbicides at different times would be unlikely to cause simultaneous residues within the body.

Third, exposures to the herbicides, especially for the public, are normally quite small. The greater exposures considered in the routine-worst case scenarios would occur only very infrequently, and the probability of the accidental exposures is extremely low. Because the probability of a large exposure is small for any one chemical, the probability of large exposures simultaneously to multiple chemicals is negligible. This is because the probability of two independent events occurring simultaneously is the product of the probabilities of the individual events. For example, if the probability of a person receiving a given exposure is 1 in 1,000 for 2 herbicides, then the probability of receiving that exposure to both herbicides would be 1 in 1 million.

Simultaneous exposure to more than one chemical is likely in cases where those chemicals are combined in a single spray mixture. Although the great majority of vegetation control projects in the Region involve only a single herbicide, a number of acres are treated with mixtures of herbicides. However, the only herbicide mixtures used are combinations

that have been approved for use by the Environmental Protection Agency.

There is some uncertainty about the risk arising from one particular combination: atrazine and simazine. As discussed in Section 3, the formulation known as Fogard S R containing both atrazine and simazine was indicated to be carcinogenic in mice in a preliminary test. This effect could be interpreted as a synergistic effect of simazine and atrazine because chronic studies of atrazine and simazine individually have produced no evident carcinogenic effects. Another possible explanation would be that some other element of the formulation was involved in causing the tumors. Conclusive carcinogenicity studies have not been done to follow up the Fogard S R study, so a worst-case assumption would be that combinations of atrazine and simazine are carcinogenic. However, atrazine and simazine are not generally used in the Region for combination treatments.

Cumulative Effects

The total area of U.S. Forest Service land in Washington and Oregon and BLM land in western Oregon is 38,000 square miles. This area makes up about one-fourth of the total land area (165,000 mi^2) of those two States. In a given year, the Forest Service and BLM may treat up to 156 mi^2 (100,000 acres) with herbicides for vegetation management. The treated area would thus comprise less than one-thousandth (less than 0.1 percent) of the total land area of the two States. Moreover, the treatments would occur for the most part in the remote areas of these either densely forested or range lands. In general, treatment units are sprayed only once in a given year, then not treated again until a number of years later. The later treatment also may be with a different herbicide.

No one individual member of the public is likely to receive repeated exposures to any of the herbicides because of the remoteness of most treatment units, the widely spaced timing of repeated treatments, and the use of a variety of herbicides for different purposes. In addition, the precautions taken by the Forest Service and BLM in their treatment operations make any dose at all to the public quite unlikely. This risk assessment used the lowest NOEL's found in chronic animal laboratory studies for comparison with estimated human doses. The risk analysis results showed that, except for amitrole and triclopyr, margins of safety for the public from realistic treatment scenarios are greater than 200. Thus, members of the public could receive doses of these herbicides repeatedly over the years, even though the chance of receiving multiple doses is negligible, and still not suffer toxic effects. Some individuals who may be particularly sensitive to amitrole or triclopyr may experience ill effects but, again, this should occur only in the unusual circumstance of repeated doses. Compared to the levels of exposure to the pesticides used in agriculture and related commercial operations in Washington and Oregon, the exposures to humans from Forest Service and BLM operations from year to year would be insignificant. Therefore, cumulative effects on the public should be negligible.

Cumulative effects on workers have been considered throughout this analysis. The risk of workers experiencing toxic effects, including cancer, assumes that they are chronically exposed to these herbicides. Backpack applicators are at greatest risk from cumulative effects.

Populations at Risk

The populations at risk in herbicide spraying operations in the Pacific Northwest fall into three categories: (1) workers involved in the spray operations, (2) forest users such as hikers, hunters, and fishermen, and (3) residents of dwellings in and near the forest.

The number of workers involved in spraying operations for a typical spray year for the Forest Service and BLM is discussed in Section 2. The number of forest visitors to Forest Service and BLM land is recorded as visitor days by the agencies. The Forest Service in Region 6 averages approximately 30 million total visitor days annually. Total visitor days for BLM averages about 2 million annually in western Oregon. The number of residents living within a specified distance of Forest Service and BLM land are shown in Table 5-16.

Again, because of the remote locations of most herbicide application sites, no member of the public should be exposed in the vast majority of operations. Silvicultural operations present the least probability of exposure, while right-of-way and facilities maintenance operations present the greatest probability of exposure.

The only possibility for exposure beyond one-half mile distance is in the extremely unlikely event of an accidental worst case spill. BLM estimates that the number of people living within a mile of its land in western Oregon is approximately 130,000. The Forest Service estimates that the number of residents with a mile of its land is approximately 100,000.

Table 5-16 Number of Residents

Distance	Forest Service land	BLM land
1/4 mile	29,831	30,357
1/2 mile	50,919	53,395

Section 6
List of Preparers

This risk assessment was prepared by an interdisciplinary team of environmental scientists, ecosystem modelers, and toxicologists. Members of the Forest Service and BLM listed here provided the background information on vegetation management operations and herbicide use in Washington and Oregon and were the principal reviewers at each stage of its preparation. Many other members of the Forest Service and BLM not listed here participated in the review process.

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All documents referenced in the Supplement are available at universities, at libraries, or from Federal agencies such as the Forest Service or the U.S. Environmental Protection Agency (EPA). All EPA documents can be obtained through requests to EPA's Freedom of Information Office, Washington, D.C. 20460.

In the text of this document references are cited in parentheses using the author-year system of citation. When an organization (such as a Government agency or scientific society) is listed as the author in the parenthetical citation, an acronym or an abbreviated form of that organization's name generally is used in place of its full title. Below is a list of acronyms and abbreviations that are used in citations, along with the corresponding full titles that are used in this reference section.

BLM U.S. Department of the Interior, Bureau of Land Management
DOE U.S. Department of Energy
EPA U.S. Environmental Protection Agency
NCI National Cancer Institute
OSTP U.S. Office of Science and Technology Policy
USDA U.S. Department of Agriculture
WSSA Weed Science Society of America

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GLOSSARY

A

Acceptable Daily Intake (ADI). The maximum dose of a substance that is anticipated to be without lifetime risk to humans when taken daily.

Acetone. A colorless, volatile liquid that is useful as a solvent. It is found in the blood and urine when fats are not properly metabolized.

Acid Equivalent (a.e.). The amount of active ingredient expressed in terms of the parent acid.

Active Ingredient (a.i.). The chemical in a herbicide that is primarily responsible for its phytotoxic or herbicidal action.

Acute Toxicity. The quality or potential of a substance to cause injury or illness shortly after exposure to a relatively large dose.

Adenoma. An abnormal growth of glandular tissue.

Adenocarcinomatous. Referring to a malignant (cancerous) adenoma.

Adsorption. Adhesion of substances to the surfaces of solids or liquids. Technically, the attraction of ions of compounds to the surfaces of solids or liquids.

Ames Assay. A type of short-term test using bacteria in laboratory cultures to assess the mutagenic potential of a substance.

Assay. A test or measurement used to evaluate a characteristic of a chemical. See Bioassay.

Atopic. Displaced or not located in the usual position.

B

Bacteriophage. A group of transmissable agents (bacterial viruses) capable of destroying certain bacterial cells.

Bile Ducts. Passages that convey the bile from the liver and gall bladder to the small intestine.

Bioaccumulation. The process of a plant or animal selectively taking in or storing a persistent substance. Over a period of time, a higher concentration of the substance is found in the organism than in the organism's environment.

Bioassay. A method for quantitatively determining the concentration of a substance by its effect on a suitable animal, plant, or microorganism under controlled conditions.

Boom (herbicide spray). A tubular metal device that conducts an herbicide mixture from a tank to a series of spray nozzles. It may be mounted beneath a helicopter or a fixed-wing aircraft or behind a tractor.

Buffer Strip/Zone. A strip of vegetation that is left or managed to reduce the impact that a treatment or action on one area would have on another area.

C

Carcinogenic. Capable of producing or inciting cancer.

Carcinoma. A malignant or cancerous tumor.

Chemical Degradation. The breakdown of a chemical substance into simpler components through chemical reactions.

Cholangiofibrosis. An abnormal formation of fibrous tissue within the bile duct of the gall bladder.

Chromosome. Microscopic structures within the cell that are composed of DNA and the genes (hereditary determiners).

Chronic (effects or toxicity). Having poisonous or deleterious effects from prolonged exposure or repeated administration of a chemical.

Conifer. An order of the Gymnospermae, comprising a wide range of trees, mostly evergreens that bear cones and have needle-shaped or scalelike leaves; timber commercially identified as softwood.

Crossing Over. The breaking and exchanging of parts of chromosomes between chromosome pairs during cell division.

Cytogenetic. Refers to the structure or function of chromosomes within cells.

D

Degradation. See chemical degradation.

Dermal Exposure. That portion of an amount of toxic substance that an organism receives as a result of the substance coming into contact with the organism's body surface.

Dislodgeable Residue. A pesticide residue that can be removed from surfaces such as foliage by physical contact.

DNA. Deoxyribonucleic acid. Any of various nucleic acids that are the molecular basis of heredity in many organisms.

Dominant Lethal Assay. A toxicity test whereby a male animal (usually arodent) is exposed to a chemical substance and later sequentially mated with two female animals. The females are sacrificed, and the number and status of the fetuses is recorded.

Dose. The amount of chemical administered or received by an organism, generally at a given point in time.

Drift. That portion of a sprayed chemical that is moved by wind off a target site.

E

Ecosystem. An interacting system of organisms considered togetherwith their environment; for example, marsh, watershed, and lake ecosystems.

Environmental Impact Statement (EIS). A formal document to be filed with the Environmental Protection Agency that considers significant environmental impacts expected from implementation of a major Federal action.

***E. coli* or *Escherichia coli*.** A common species of bacteria used in many areas of biological research, including mutagenicity testing.

Ester. A compound formed by the reaction of an acid and an alcohol, generally accompanied by the elimination of water.

Exposure Analysis. The estimation of the amount of chemical that is in an organism's environment and available for uptake into the body.

F

F_0. In genetics and reproduction studies, it pertains to the first parents' generation.

F_1. In genetics, it refers to the first generation of offspring from the F_0 generation.

Fate. The course of an herbicide in an ecosystem or biological system after it has been applied; including metabolism, microbial degradation, leaching, and photodecomposition.

Fetotoxic. Capable of producing adverse effects in a developing fetus.

Fibroblast. Any cell from which connective tissue is developed.

Formulation. A chemical mixture that includes a certain percentage of active ingredient (technical chemical) with an inert carrier.

G

Gavage. Feeding by way of a tube inserted into the stomach.

Gene. The basic unit of heredity. Each gene occupies a specific place (locus) on a chromosome.

Genotoxic. Harmful to genetic material (DNA).

Germ Cell. A functional sex cell that combines with the opposite sex cell for fertilization, for example, sperm, egg.

Global 82. A computer program by Howe and Crump (1982) used to fit the multistage or one-hit models to experimental cancer data.

H

Half-Life. The amount of time required for half of a compound to degrade.

Hazard Analysis. The determination of whether a particular chemical is or is not causally linked to particular harmful effects.

HDT. Highest dose tested.

Hectare (ha). 10,000 square meters, or approximately 2.47 acres.

HeLa Cell Line. A human cell line originally derived from cancerous breast cells.

Hematocrit. The percentage by volume of red blood cells in a given volume of blood.

Hemoglobin. The iron-containing compound in red blood cells that functions to carry oxygen from the lungs to the tissues.

Hepatoma. A tumor of the liver.

Herbaceous. A plant that does not develop persistent woody tissue above the ground.

Herbicide. A chemical used to control, suppress, or kill plants, or to severely interrupt their normal growth processes.

Heritable. Capable of being passed on from parents to offspring.

Histology. The study of the microscopic structure of tissue.

Histopathologic. Referring to tissue changes characteristic of disease.

Hydrolysis. Decomposition or alteration of a chemical substance by water.

Hyperplasia. An excessive proliferation of normal cells in the tissue of an organ.

Hypertrophy. An increase in size of an organ or structure that does not involve tumor formation.

Hypohatchet. A tool used to inject herbicide into a tree trunk or woody stem.

I

In Vitro. Pertaining to a test that is conducted outside the living body and in an artificial environment such as a test tube or petri dish.

In Vivo. Pertaining to a test that is performed within the living body of the organism.

Intraperitoneal. Related to a structure or process occurring within the peritoneum, a membranous lining of the body cavity.

Intravenous. Within or into a vein.

K

Kilogram (kg). One thousand grams; or approximately 2.2 pounds.

L

Label. All printed material on or attached to a pesticide container as required by law.

Latency Period. The time between a stimulus and its response.

LC_{50}. A lethal concentration rate at which 50 percent of the test animals will be killed. It is usually used in the testing of fish or other aquatic animals.

LD_{50}. The dosage of toxicant, expressed in milligrams of toxicant per kilogram of animal body weight, required to kill 50 percent of the animals in a test population when given orally.

LDT. Lowest dose tested.

Leach. Usually refers to the movement of chemicals through soil by water; may also refer to the movement of herbicides out of leaves, stems, or roots into the air or soil.

Least Squares Estimation. A mathematical approach used to fit a straight line (or other models) so that the sum of the squares of the vertical distances of the data points from the line will be a minimum.

Lowest Effect Level (LEL). The lowest dose tested that results in an effect in a test organism.

Linear Regression. A mathematical procedure used to draw a straight line that best fits a set of data points on a graph.

Log-Probit Model. An equation used to describe the relationship between dose and the probability of contracting cancer. This equation can be derived by assuming that humans (or animals) have various susceptibilities, but that at very low doses none has a significant risk.

Lymphocyte. A cell of the lymphatic system, or a special type of white blood cell.

Lymphoma. A general term for the growth of new tissue in the lymphatic system.

M

Malignant. Used in reference to a tumor; indicating the presence of cancer and tending to grow worse and spread within an organism.

Margin of Safety (MOS). The ratio between the no-observed-effect level (NOEL) and the estimated dose.

Metabolism. The chemical changes in living cells by which energy is provided for vital processes and new material is assimilated.

Metabolite. A product of the chemical changes in living cells that provide energy and assimilate new material.

Microbial Degradation. The breakdown of a chemical substance into simpler components by bacteria or other microorganisms.

Microgram (ug). One millionth of a gram.

Mitigation Measures. Means taken to avoid, compensate for, rectify, or reduce the potential adverse impacts of a proposed action.

Mitotic. Pertaining to the process of cell division that results in twocells having the same number of chromosomes as the original cell.

Multistage Model. An equation used to describe the relationship between dose and the probability of contracting cancer. This equation, commonly used

by EPA, assumes that several successive events must occur to produce cancer.

Mutagen. A substance that tends to increase the frequency or extent of genetic mutations (changes in hereditary material).

Mutagenic. Capable of producing genetic defects in an organism.

N

Necrosis. Death of a cell or group of cells as a result of injury, disease, or other pathologic state.

Neoplastic. Pertaining to new abnormal tissue formation (neoplasms).

Neuropathy. Any disease affecting neurons, the fundamental functional units of nervous tissues.

NOEL (no-observed-effect level). The dose level at which no toxic effects are observed in a test organism.

Noxious Weed. A plant regulated or identified by law as being undesirable, troublesome, and difficult to control.

Nucleic Acid. A group of complex molecules found in cells, composed of phosphoric acid, sugars, and nitrogen bases. Includes DNA and RNA.

O

ODT. Only dose tested.

Omphalocele. A congenital hernia of the navel.

Oncogenic. Capable of producing or inducing tumors in animals, either benign (noncancerous) or malignant (cancerous).

Oncology. The branch of medicine which studies tumors.

One-Hit Model. An equation used to describe the relationship between dose and the probability of contracting cancer. This equation, used at one time by EPA, predicts the greatest cancer probability at low doses of all commonly used models.

Organic Material. An accumulation of decayed and resynthesized plant and animal residues with a high capacity for holding water and nutrients.

Ossification. The formation of bone.

P

Papillary. Resembling or composed of small protuberances or elevations.

Parenteral. Injection of a substance into the body through any route other than the digestive tract.

Particulates. Finely divided solid or liquid particles in the air or in an emission; includes dust, smoke fumes, mist, spray, and fog.

Pathology. The study of the nature and cause of disease with respect to functional and structural changes.

Persistence. The resistance of a pesticide to metabolism and environmental degradation.

Pesticide. As defined by FIFRA, any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Photochemically Reactive. A property of substances or particles whose structures may be changed when solar energy is absorbed.

Photolysis (photodecomposition). The breakdown of a substance, especially a chemical compound, into simpler components by the action of radiant energy such as sunlight.

Photosynthesis. Formation of carbohydrates in the tissues of plants exposed to light.

Phytotoxic. Injurious or lethal to plants.

Pituitary Gland. A small, oval endocrine gland attached by a stalk to the base of the brain and consisting of an anterior and a posterior lobe; it secretes hormones that influence body growth, metabolism, and so forth; hypophysis.

ppm (parts per million). A unit for measuring the concentration of a substance, such as a pesticide, in a carrier medium, such as food or water. For example, where the concentration is 1 ppm, the weight of the substance is 1 millionth the weight of the carrier medium; thus, 1 ppm is equal to 1 milligram of substance per kilogram of food or organism body weight, and it is equal to 1 milligram of substance per liter of water.

Proliferation. The rapid and repeated reproduction of new cells.

Pulmonary. Concerning or involving the lungs.

Pyrolysis. Chemical breakdown caused in the process of combustion.

R

Recreation Visitor Day (RVD). Twelve visitor hours, which may be aggregated continuously, intermittently, or simultaneously for one or more persons.

Reentry. The return of a worker to an area that has recently been treated with a pesticide.

Renal Tubule. The functional unit of the kidney where urine is formed; nephron.

Residue. The quantity of a herbicide or its metabolites remaining in or on soil, water, plants, animals, or surfaces.

Resorption. Act of removal by absorption.

Risk Analysis. The description of the nature and often the magnitude of risk to organisms, including attendant uncertainty.

Runoff. That part of precipitation, as well as any other flow contributions, that appears in surface streams, either perennial or intermittent.

S

Safety Factor. A factor conventionally used to extrapolate human tolerances for chemical agents from no-observed-effect levels in animal test data.

Salmonella. A genus of bacteria used in mutagenicity testing.

Sediment. Organic matter or soil that settles to the bottom of a liquid.

Shrub. A plant with persistent woody stems and relatively low growth form; usually produces several basal shoots as opposed to a single bole; differs from a tree by its low stature and nonarborescent form.

Silviculture. The branch of forestry dealing with the care,development, and reproduction of forest trees or stands of timber.

Sister Chromatid Exchange (SCE). A short-term test conducted with laboratory cell cultures to assess the genetic damage caused by a chemical or physical influence.

Spot Treatment. Application of a herbicide to a small selected area as opposed to broadcast application.

Subchronic. The effects observed from doses that are of intermediate duration, usually 3 months (90 days).

Subcutaneous. Beneath the skin, or to be introduced beneath the skin.

Surfactant. A material that improves the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of liquids.

Systemic Herbicide. An herbicide that is moved within the plant. In a more restricted sense, refers to herbicides that are applied to the foliage and move downward through the living tissue to underground parts.

Systemic Toxicity. Effects produced as a result of the distribution of a poison or foreign substance from the point of exposure to a distant site within the body.

T

T_3. Triiodothyronine. A chemical measured in tests which evaluate the functioning of the thyroid gland.

T_4. Tetraiodothyronine. A chemical measured in tests which evaluate the functioning of the thyroid gland.

Teratogen. A substance tending to cause developmental malformations in unborn human or animal offspring.

Teratogenesis. The development of abnormal structures in an embryo.

Teratogenic. Capable of producing or inciting the development of malformations in an embryo.

Teratology. The study of malformations in organisms.

Thiourea. A colorless crystalline form of urea containing sulfur in place of oxygen.

Thymus. A relatively small organ located in the upper chest that is important in the development of the immune system in newborn and young animals.

Thyroid Gland. A large, ductless gland lying in front of and on either side of the trachea and secreting thyroxine which regulates growth of the body.

Thyroid Stimulating Hormone (TSH). A chemical secreted by the pituitary gland intended to cause the thyroid gland to produce its hormones.

Toxicity. A characteristic of a substance that makes it poisonous.

Toxicology. The science dealing with the study of the adverse biological effects of chemicals.

Tumor. A new growth of tissue that forms an abnormal mass and performs no physiologic function. It usually develops independent of and unrestrained by the normal principles of biological growth.

Tumorigenesis. The formation and/or development of a tumor (oncogenesis).

V

Volatility. The quality of evaporating readily at normal temperatures and pressures.

Volatilization. The vaporizing or evaporating of a chemical substance.

W

Wettable Powder (WP). A finely divided dry formulation that can be readily suspended in water.

Attachment A DETAILS OF MUTAGENICITY AND CARCINOGENICITY TESTING

MUTAGENICITY

This subsection presents the details of mutagenicity tests conducted on amitrole, atrazine, bromacil, 2,4-DP, and dicamba.

Amitrole

The mutagenic potential of amitrole is summarized by the following information from EPA (1985a):

> Amitrole has been evaluated in a variety of mutagenicity test systems. Although positive results were reported by Braun et al., 1977, (using added nitrite) in *Salmonella* and by Venitt and Crofton-Sleigh (1981) in *Salmonella* and *E. coli*, 49 other *Salmonella* gene mutation tests and 7 other *E. coli* tests were negative. The validity of the two positive studies is questionable. The weakly positive results by Carere et al. (1976, 1978, and 1981) were in an unvalidated system using unusual bacteria. The mechanisms for these positive results reported for the DNA repair assays cannot be determined without positive gene mutation or chromosome aberration assays. The negative results in the sister chromatid exchange assay in mammalian cells in culture (which is a very sensitive assay) and the chromosome aberration assays in cultured human lymphocytes or in vivo mouse bone marrow cells cast doubt on the significance of the DNA repair assays. Amitrole does not present a potential for heritable genetic effects.
>
> Amitrole is able to induce transformation of cultured cells. It was positive in four in vitro transformation studies using rat and hamster cells (Pienta, 1977; Inoue, 1981; Dunkel, 1981; Styles, 1981) following treatment of 0.1 to 100 ug/ml. This test is used to establish the malignant activities of test compounds on mammalian cells in vitro. Cells treated in vitro with chemical carcinogens give rise to foci of cellular growth superimposed on the cell monolayer. If these foci are picked from the cultures, grown to larger numbers, and injected into animals, a malignant tumor will be obtained, in most cases. Therefore, the appearance of piled-up colonies in treated cell cultures is correlated with malignant transformation. In addition, weak cellular transformation capacity was observed in EUE cells (no data presented, only summary) (Benigni, 1980).
>
> These transformation assays are not able to determine a mechanism for tumor formation and do not necessarily show that a transformation inducer is genotoxic. These results support oncogenicity potential but not necessarily mutagenicity potential.

Atrazine

Atrazine did not induce mutations in microbial assay systems evaluated by EPA (1984c). All of the following positive results were reported in USDA (1984). Atrazine represents an unusual situation because many of the positive genotoxicity studies were conducted using a metabolic activation system of plant origin. Atrazine alone or when tested in vitro in tests using animal metabolic systems was not genotoxic in most cases. Because plant metabolism is not generally considered important in developing a human hazard assessment, the relevance of the "plant-activated" tests in a risk analysis is doubtful.

Atrazine is not genotoxic in bacteria or yeast directly or with the typical rodent S9 activation. Yeast tests for mitotic crossing over and mutation do show positive responses, but only when tested with atrazine incubated with plant cell extracts. Bacteriophage T4 mutation and a *B. subtilis* test for repairable DNA damage were negative with atrazine alone. A *Streptomyces coelicolor* mutation assay was positive, but this assay appears to have very little reliability to discriminate true positives and false positives.

In vitro tests with mammalian cells also fail to respond to atrazine directly or with mammalian metabolism (aberrations and sister chromatid exchange tests in hamster cells were negative), but when hamster V79 cells were exposed to atrazine in the presence of plant cell extracts, the chemical was reported to be mutagenic. Positive unscheduled DNA synthesis (UDS) effects in EUE cells were also reported with atrazine plus plant cell extracts.

Atrazine was reported to be genotoxic directly in plants (mutations at the waxy locus in corn; locus in corn; chromosome aberrations in plant cells) and the mold *Aspergillus nidulans* (crossing over). Mutation studies in *Aspergillus* were conducted with plant cell extracts. In the presence of plant cell extracts, a mutation to 8 azaguanine resistance was reported for *Aspergillus*.

Atrazine was reported to induce sex-linked recessive lethal mutations in the fruit fly (*Drosophila melanogaster*) in one of two studies.

In vivo studies measuring chromosome aberrations in rodent bone marrow and dominant lethal mutations in the mouse were reported positive at dose levels of 2,000 and 1,500 mg/kg, respectively.

Positive responses in the Drosophila sex-linked recessive lethal assay (which measured gene mutations in germ cells) and the mouse dominant lethal assay (which measured chromosome alterations in germ cells) both indicate a potential for mutagenic hazard. Bone marrow chromosome aberration effects support this conclusion. The in vivo responses were observed only at very high levels of atrazine equal to or exceeding 1.5 gm/kg.

Bromacil

The mutagenicity studies submitted to EPA for the registration of bromacil were deemed unacceptable; therefore, no validated mutagenicity studies have been completed (EPA, 1984d).

Because of the potent mutagenicity of 5-bromouracil, which is a structurally related chemical, the metabolic fate of bromacil has been examined to determine whether the formation of 5-bromouracil occurs in vivo. Metabolic fate studies indicate that 5-bromouracil was not isolated from the urine and feces of rats exposed to bromacil or from the urine of bromacil production plant workers (DOE, 1983).

2,4-DP

A very limited assessment of the genotoxicity of 2,4-DP is available. 2,4-DP was nonmutagenic when tested in three nonactivated microbial assays (EPA, 1984f). 2,4-DP was not mutagenic to *Salmonella* in the Ames test. A sample was tested for induction of repairable DNA damage in *E. coli*. The results were positive with metabolic activation. Positive results were obtained when 2,4-DP was tested in the nonactivated *Saccharomyces cerevisiae* reverse mutation assay, the *Saccharomyces cerevisiae* mitotic gene conversion assay, and the activated *E. coli* assay for unscheduled DNA synthesis (EPA, 1984f).

A single in vivo micronucleus study in mice was conducted, but results were not reported because the study was concluded to be invalid by EPA.

Dicamba

Dicamba was nonmutagenic when tested in various microbial assays for gene mutations and a dominant lethal assay with mice (USDA, 1984). Positive mutagenic responses were observed when dicamba was tested in the *B. subtilus* and *E. coli toxicity assays for primary DNA damage (USDA, 1984); however, these tests are not useful in determining human mutagenic potential.*

CARCINOGENICITY

This subsection presents the details of oncogenicity tests conducted on amitrole, asulam, atrazine, bromacil, 2,4-D, 2,4-DP, glyphosate, picloram, and simazine.

Amitrole

Amitrole has been shown to induce a high incidence of thyroid tumors in laboratory animals. Amitrole also induces liver tumors in mice when fed at levels in excess of the maximum tolerated dose; it also produces thyroid carcinomas along with the liver tumors (EPA, 1984a; EPA, 1985a).

Amitrole is an antithyroid compound that resembles thiourea in its effect on the thyroid gland. Prolonged administration leads to a reduction in the levels of circulating thyroid hormones and a compensatory increase in the production of thyroid stimulating hormone (TSH). This results in enlargement of the thyroid (goiter) and in adenomatous (tumor growth of the glandular epithelium) changes.

There has been some disagreement among pathologists regarding the nature of the changes that have been induced in the thyroid glands of treated laboratory animals in some experiments. Some pathologists interpreted some of the changes to be cancerous, while others judged them to be nonmalignant (e.g., Jukes and Shaffer, 1960). In a 2-year rat feeding study conducted by Hazleton Laboratories, Inc., rats fed 100 ppm of amitrole had greater than 50 percent (15 of 27) incidence of thyroid adenoma. In rats fed 10 and 50 ppm, the incidence was lower (1 of 27 and 3 of 27, respectively), and there were no adenomas in the control group (Hodge et al., 1966; Jukes and Shaffer, 1960). In another 2-year rat feeding study by Bayer (1979, cited in EPA, 1985a), significant increases in thyroid tumors were observed at 100 ppm. Also, when rats were pulse-fed amitrole alternating with a control diet in an effort to minimize thyroid stimulation, significant increases in thyroid tumors were observed at the higher dose levels (Food and Drug Research Lab, 1981, cited in EPA, 1985a).

In another experiment, rats were fed 2,500 ppm in their drinking water for 70 weeks (Tsuda et al., 1976). Of 26 surviving rats, 100 percent had goiter development, and 73 percent had invasive thyroid lesions, and 11.5 percent had papillary adenoma. In two rats, liver damage occurred because of irregular proliferation of the bile ducts. Two other rat feeding studies and one hamster study found no increase in thyroid tumor incidence (EPA, 1985a).

Most exposures to workers and the public can be expected to be dermal, and dermal exposure in a mouse study did not yield similar effects. In a long-

term (575 days) mouse study, subcutaneous injections (10 mg/mouse) and weekly skin applications in acetone produced no tumors (Hodge et al., 1966).

Other studies have shown that amitrole can produce liver tumors. For example, Feinstein et al. (1978) induced liver tumors by feeding high levels of amitrole to mice. When mice were fed 1 percent amitrole in their diets for 1 year, during 4 out of each 5 weeks, 100 percent of them developed liver tumors by 1 year after weaning. Only a few mice had thyroid tumors. However, this strain of mice (C3H) has a high natural incidence of liver tumors, and the concentration of amitrole given was so high that survival was affected for other reasons. Innes et al. (1969) also reported the induction of liver tumors in mice by amitrole. However, in this study, the doses also were so high (2,192 ppm) that survival was affected. Several other studies have reported no increase in the incidence of liver tumors (EPA, 1985a).

In some studies, amitrole has also been shown to cause pituitary tumors. In a 2-year rat study, pituitary tumors were increased at 100 ppm in females (Bayer, 1979, reported in EPA, 1985a). In another 2-year study, female rats had a significant incidence of pituitary tumors at the highest dose tested (100 ppm), whether it was administered continuously or intermittently (Food Drug Research Lab., 1981, reported in EPA, 1985a).

EPA has classified amitrole in Category B 2 , indicating that it is a probable human carcinogen (EPA, 1985a). EPA has also stated in its Amitrole Toxicology Summary that the scientific evidence "strongly supports the use of a threshold approach in assessing the oncogenic risk of amitrole, realizing, however, that this is a radical departure from previously used risk assessments" (EPA, 1985a). EPA also concluded that amitrole is not mutagenic, and animal data suggest a "secondary carcinogenic" effect due to increased production of thyroid-stimulating hormone (EPA, 1985a). Consequently, EPA has suggested the use of a log-probit model in carcinogenic risk estimation for thyroid and pituitary tumors to better represent the threshold effect (EPA, 1985a). However, EPA has also used the multistage model in its risk assessment on thyroid tumors for comparison with the log-probit model predictions and for the assessment of risk from liver tumors (EPA, 1985a). One report not considered by EPA has suggested that amitrole may act via a mutation mechanism, indicating that caution may be warranted in low-dose extrapolation (Tsutsui et al., 1984).

Asulam

Asulam was oncogenic in one of three studies conducted. Two studies with mice resulted in no oncogenic effects after 18 months at the highest dose tested of 5,000 ppm (750 mg/kg/day).

A 107-week feeding study with rats resulted in a statistically significant increase in carcinoma of thyroid c cells at 1,000 ppm (20 mg/kg/day) in males. A significant increase in adrenal medullary hyperplasia was observed in males at 25,000 ppm (EPA, 1985d; EPA,1983).

Atrazine

In an 18-month mouse feeding study, atrazine did not induce any tumors at 12.5 mg/kg/day (Innes et al., 1969). EPA has requested additional oncogenic studies on atrazine.

Preliminary studies conducted to evaluate the carcinogenic potential of Fogard S R (25 percent atrazine and 37.5 percent simazine) resulted in the formation of malignant lymphomas in mice after exposure to doses equivalent to 0.104 mg/kg of atrazine for a 7-month test period (Donna et al., 1981). The doses were given by subcutaneous and intraperitoneal injection. Tumor formation occurred as a result of both types of injection. The numbers of test animals were relatively small. Of the 24 mice receiving subcutaneous injections, 4 developed tumors, and of the 20 mice receiving intraperitoneal injections, 2 developed tumors. It is possible that the tumor formation observed in this study may be a function of the route of administration or a result of other chemicals in the formulation because atrazine and simazine have not been shown to be carcinogenic in other chronic studies, even at much higher doses.

N-Nitrosoatrazine

N-Nitroso derivatives of atrazine are carcinogenic to laboratory animals and mutagenic (Krull et al., 1980). Concerns have been raised over the potential for the nitrosation of atrazine to N-Nitrosoatrazine (NNA) under field conditions and over the potential toxicity of this compound.

Kearney et al. (1977) examined the formation and degradation of N-Nitrosoatrazine in soils and aquatic environments. Their results indicate that the formation of NNA is highly unlikely under normal application rates of atrazine (2 ppm) in agricultural soils of pH 5 to 7. They used elevated levels of nitrogen fertilizer (approximately 100 ppm) that are much higher than those used in forestry. Most of the NNA added to soil was converted relatively quickly to atrazine by denitrosation.

The degradation of NNA in aquatic environments is very rapid primarily because of photolysis (Wolfe et al., 1976).

Bromacil

Bromacil was oncogenic in one of two studies conducted. No oncogenic effects were observed in rats at doses up to 1,250 ppm (62.5 mg/kg/day) and 2 years of exposure. Liver tumors (hepatocellular adenomas) were observed in an 18-month study with mice at doses of 5,000 ppm (750 mg/kg/day) (EPA, 1985e).

2,4-D

Studies on whether 2,4-D is carcinogenic have evoked disagreement among experts. The two studies considered most acceptable (Innes et al., 1969, and Hansen et al., 1971) have resulted in negative conclusions about 2,4-D's ability to cause cancer. The following discussion summarizes the uncertainty about the potential of 2,4-D to cause cancer (BLM, 1985).

Both studies' negative conclusions about 2,4-D's carcinogenicity have been accepted by the Federal Insecticide, Fungicide and Rodenticide Act Scientific Advisory Panel for the United States Environmental Protection Agency (EPA), the editor and editorial board of the professional journal Toxicology and Applied Pharmacology, and the National Cancer Institute. Nonetheless, an expert, Dr. M. Rueber, based upon his reexamination of the Hansen et al. (1971) study and other studies, disputes the conclusion that a carcinogenic effect for 2,4-D was not shown (Rueber, 1979, as cited in BLM, 1985). The Scientific Advisory Panel, in their June 1980 report, characterized the dispute as follows:

> The FIFRA Scientific Advisory Panel has reviewed the chronic toxicity study on 2,4-D carried out in rats and dogs by Hansen and others which was published in Toxicology and Applied Pharmacology (TAP). In addition to peer review of this study by the editor and editorial board of TAP, the study has also been reviewed by the National Cancer Institute (NCI) and by Dr. M. Rueber. The NCI review agreed with the conclusion of the authors of this paper that a carcinogenic effect was not demonstrated for 2,4-D whereas Dr. Rueber's conclusion was that 2,4-D is carcinogenic in male and female rats and probably also in mice. In Dr. Rueber's report, he agreed that this FDA study (Hansen and others) must be considered as an acceptable study, and thus the major difference in the conclusions of Dr. Rueber and the authors of this study derive primarily from differences in the interpretation and evaluation of the rat histopathologic data. Dr. Rueber agrees with the authors of the FDA study that 2,4-D was not shown to be carcinogenic in dogs but argues that two years is an insufficient study period to detect carcinogenesis in this species. It should be pointed out that carcinogenic effects have been produced in dogs in studies of less than 2-year duration, and the 2-year period is the recommended exposure period in the current FIFRA guidelines for chronic toxicity studies in dogs. The FIFRA Scientific Advisory Panel recommends that the Agency attempt to resolve the apparent controversy between Dr. Rueber's pathological interpretation of the rat histologic findings and those of the authors of the FDA study before requesting any additional oncogenicity testing in rats with 2,4-D.

EPA has since contracted another review of the histopathologic data that did not support these contentions. EPA also required further specific toxicity studies on 2,4-D. An ongoing chronic/cancer 2-year rat feeding study will be completed in 1986. The Forest Service and BLM know of no substantiation for Dr. Rueber's interpretation of these studies.

2,4-DP

Three 2,4-DP oncogenicity studies have been submitted to EPA (EPA, 1982). One of these, an 18-month study involving Swiss-Webster CD-1 mice, was negative because the rate of incidence of the tumors that were found in the mice were unrelated to increasing doses of 2,4-DP. Some increase in the rate of hepatomas was noted in the highest dose group (300 mg/kg), but this increase was attributed to liver trauma resulting from feeding a dose greater than the maximum tolerated dose of 2,4-DP.

A 2-year feeding study with rats (EPA, 1984f) showed malignant tumor formation at all doses tested (25, 50, or 150 mg/kg).

A 2-year oncogenicity study involved Sprague-Dawley rats fed at dose levels of 0, 50, 100, and 200 mg/kg (EPA, 1982). In this study also, the highest dose group showed signs of general toxicity because they were fed more than the maximum tolerated dose of 2,4-DP. At 60 weeks, the high-dose group was reduced to 150 mg/kg because of general toxic effects. Females at all dose levels had high rates of tumor incidence, but they did not show a dose-related response. However, males showed a significant increase in the rate of incidence of malignant tumors, with a corresponding decrease in the rate of benign tumors. The males had increased levels of both pituitary carcinomas and thyroid carcinomas. Brain tumors were also observed in one group, in both males and females, although they were determined not to be treatment related.

Glyphosate

The following is a summary of glyphosate oncogenicity information from EPA (1985b):

> A treatment-related increase in the incidence of renal tumors has been found in a chronic mouse feeding study conducted with glyphosate. The tumors (renal tubule adenomas) occurred in three out of 50 male mice fed a diet containing 30,000 ppm (3 percent) glyphosate. The same type of tumor was also found in one of 50 animals fed 5,000 ppm (0.5 percent) glyphosate. The original pathology report indicated no renal tubule adenomas among 49 animals fed 1,000 ppm (0.1 percent) glyphosate or among the control animals. The registrant has recently submitted information indicating that one animal in the concurrent control group was found to have a renal tubule adenoma. The Agency has obtained the relevant slides and is reviewing this finding. The presence of one additional tumor in the control group, however, will not substantially change the conclusions set forth below.
>
> These tumor results are not statistically significant when each treated group is compared to the concurrent control.
>
> However, the tumor has rarely been found among untreated (control) mice and there is a statistically significant increase in the glyphosate treated male mice when compared to appropriate historical control findings. There is also a statistically significant dose-related trend. Therefore, the Agency considers the study to be positive for oncogenicity at this time.
>
> It should be noted that no statistically or biologically significant increases in tumors were found among female mice from the same study. In addition, a long-term oncogenic study conducted with rats was negative for oncogenicity. Several appropriately conducted and scientifically acceptable mutagenicity tests were also negative.
>
> Thus, in well-conducted oncogenicity studies on both sexes of two species, the incidence of only one tumor type in one sex of one species was found to have an increase related to treatment with glyphosate. This increase in tumors occurred only at very high exposure levels (much higher than usual in long-term studies of pesticides). Furthermore, the positive finding depends upon the presence of tumors in only four treated animals.
>
> The factors listed in the paragraph above indicate that the evidence for oncogenicity, though present, is extremely limited. According to the Agency's proposed carcinogen risk assessment guidelines (49 FR 46294), glyphosate would be classified in Category C, which is used for agents with limited evidence of carcinogenicity in animals in the absence of human data. Category C is the lowest weight-of-evidence category among the categories with any positive evidence.
>
> Because the renal tubule adenomas are small and could be missed by the usual pathology procedures, the Agency has required additional sectioning of new blocks of male mouse kidneys from this study. Results from the additional sectioning are expected to provide a numerically better basis for an oncogenicity conclusion. It is possible, therefore, that the Agency's conclusion will change after these data are received and revived. On the basis of the information currently available, however, there is weak evidence that glyphosate may be a human oncogen. The Agency expects to receive the additional information within two months. Depending upon the results of our review, we may seek advice from the FIFRA Scientific Advisory Panel.
>
> In addition to the limited amount of quantitative evidence supporting a conclusion of oncogenicity, a quantitative risk estimate indicates that, to the extent that glyphosate is actually an oncogen, it is likely to have only a weak oncogenicity effect. This is primarily related to the extremely high doses at which effects were observed in the study as compared to likely human exposure. Therefore, based on the information currently available, the Agency does not expect any significant risk from the level of glyphosate to which humans are likely to be exposed.

Monsanto claims that the data indicate no evidence of carcinogenicity in male or female rats and female mice. Also, extensive mutagenic testing has proven negative. However, some concern arose over the response of the male mice. While no specific male treatment group showed any statistically significant increase in cancer incidence, further analyses revealed a significant trend in rate of production of renal tumors at the P 0.05 level. Monsanto then contracted the services of an independent pathologist to review the kidney slides. The consultant's judgment was such that a previously unrecognized renal tumor was found in the controls. No other difference from the original analysis was reported. The significance of the Monsanto consultant's finding along with the negative rat data and earlier negative 2-year dose studies led Monsanto to conclude that glyphosate is not carcinogenic.

Dr. Edward Calabrese (see list of preparers) has reviewed both EPA's and Monsanto's findings and believes that no final decision on the carcinogenicity of glyphosate can be reached until a number of

issues have been resolved, one of which is an independent pathologist's review of the Monsanto data.

N-Nitrosoglyphosate

N-Nitroso derivatives of some herbicides are carcinogenic and mutagenic (Young and Khan, 1978; Braun et al., 1977). It has been suggested that the herbicide glyphosate may include N-Nitrosoglyphosate (NNG) as a trace contaminant, or that the compound may be formed in the environment after herbicidal application (Dost, 1983; Newton et al., 1984). However, EPA has determined that NNG does not occur as a contaminant in significant amounts in the herbicide glyphosate to pose a hazard to human health (Dost, 1983). Newton et al. (1984) found traces of NNG (approximately 0.02 ppm) in one foliage sample and one forest litter sample after aerial application of glyphosate; however, they concluded that this may have been because of the evaporation procedure used in the analysis.

Nitrosation in soil generally requires elevated nitrite levels and a pH of 3 to 4. Nitrite levels in forest area soils are generally much less than those in agricultural soils. Several studies have been conducted to measure the the extent of nitrosation of glyphosate in soil with respect to temperature, pH, and organic matter content (Khan and Young, 1977; Young and Khan, 1978). NNG formed in several types of soil that were treated with glyphosate and nitrite. Levels of 5 ppm of NNG were reached when glyphosate was applied at approximately 185 ppm. This application rate is 90 to 100 times greater than normal rates. No NNG formed at glyphosate concentrations of 5 ppm and nitrite concentrations of 2 ppm. It was concluded that NNG is not likely to form in soils at the recommended application rates of 2.24 kg/ha, which is similar to application rates used in forestry.

Picloram

There is scientific controversy concerning the interpretation of studies on the potential of picloram to cause cancer. A rat oncogenicity study, during which test animals were exposed to an average of 14,875 ppm (743 mg/kg/day), was negative for oncogenic effects in males. Neoplastic nodules were observed in females at a statistically significant rate (EPA, 1984q). An oncogenic mouse study resulted in the absence of oncogenic effects at dietary exposure levels ranging from 5,000 to 15,000 ppm (750 mg/kg to 2,250 mg/kg)(EPA, 1984q and EPA, 1984m). Because there is some uncertainty regarding the potential for carcinogenicity of picloram, a worst case approach was taken to calculate cancer risks.

The Gulf Research Institute conducted a carcinogenic bioassay of picloram in rats and mice for the National Cancer Institute (1978). The mouse study produced no indication of an oncogenic response resulting from dietary exposure. Exposure consisted of as much as 5,000-plus ppm in the diet for the greatest part of their lifetime (as cited in EPA, 1984m).

The rat study, however, was negative for oncogenic effects in males, while female rats exhibited a statistically significant increase over control rats in the rate of formation of neoplastic nodules in the liver. Exposures ranged on a time-weighted average up to 14,875 ppm in the diets (743 mg/kg) (as cited in EPA, 1984m). The study concluded that the findings were "suggestive of ability of the compound to induce benign tumors in livers of female Osborne-Mendel rats."

According to a classification scheme developed by the National Cancer Institute (NCI), picloram was classified as a chemical for which evidence of carcinogenicity in animals was equivocal at best (Griesmer and Cueto, 1980, cited in BLM, 1985). However, one scientist has interpreted the data differently and has concluded that picloram was carcinogenic for all test animals except mice at the lowest dose (Rueber, 1981). This interpretation disagrees with the panel of experts who interpreted the data for the National Cancer Institute. More research on picloram's potential carcinogenicity is currently in progress at the Dow Chemical Company and is scheduled for completion in 1986. A new rodent (rat) oncogenicity study has been in progress since March 1982.

EPA (1984q) has stated that:

> It was found that some studies on long-term effects performed by Industrial Bio-Test (IBT) Laboratories were invalid due to improper laboratory practices. In addition, a long-term study in rats sponsored by the National Cancer Institute is considered of questionable value due to laboratory procedures. The results of this rat study suggest that picloram may induce benign liver tumors. Even if this study were accepted as positive, given the high doses needed to produce the effect, and the very low potential for human exposure from current uses, existing uses would not pose a significant risk of increased cancer in the population. The registrant is conducting a new rat study to clarify the ambiguous results of this NCI study.

Simazine

In a preliminary oncogenicity study, the herbicide Fogard SR (25 percent atrazine and 37.5 percent simazine) was administered to mice for a 7-month

test period; as a result, malignant lymphomas were induced in test animals treated subcutaneously and intraperitoneally (Donna et al., 1981). As noted previously regarding atrazine, tumor formation in this study may have resulted from other chemicals in the formulation, or it may be related to the route of administration, because chronic simazine and atrazine feeding studies have shown no oncogenic effects, even at higher doses.

Attachment B
DOSES TO WORKERS AND THE PUBLIC COMPUTED IN THE EXPOSURE ANALYSIS

Doses to workers for each of the application scenarios are given in mg/kg in the following tables. Doses to the public via each exposure route and for representative members of the public are given in micrograms/kg. Doses from accidental spraying to the public are given in micrograms/kg. Doses to workers and the public from spills are given in mg/kg.

Table B-1
Doses to Workers (mg/kg) Routine-Realistic Aerial, 40 Acres by Helicopter

HERBICIDE	PILOT	MIXER/LOADER	SUPERVISOR	OBSERVER
AMITROLE	0.0004	0.0006	0.0001	0.0000
ASULAM	0.0483	0.0693	0.0074	0.0016
ATRAZINE	0.0755	0.1083	0.0116	0.0025
2,4-D	0.0302	0.0433	0.0046	0.0010
2,4-DP	0.0258	0.0370	0.0039	0.0008
DALAPON	0.0806	0.1156	0.0123	0.0026
DICAMBA	0.0101	0.0144	0.0015	0.0003
FOSAMINE	0.0604	0.0867	0.0092	0.0020
GLYPHOSATE	0.0403	0.0578	0.0062	0.0013
HEXAZINONE	0.0504	0.0722	0.0077	0.0016
PICLORAM	0.0010	0.0014	0.0001	0.0000
SIMAZINE	0.0806	0.1156	0.0123	0.0026
TEBUTHIURON	0.0201	0.0289	0.0031	0.0007
TRICLOPYR	0.0403	0.0578	0.0062	0.0013

Table B-2
Doses to Workers (mg/kg) Large Aerial, 400 Acres by Fixed Wing, Routine-Worst Case

HERBICIDE	PILOT	MIXER/LOADER	SUPERVISOR	OBSERVER
AMITROLE	0.0067	0.0085	0.0012	0.0002
ASULAM	0.5591	0.7128	0.0969	0.0173
ATRAZINE	0.6696	0.8536	0.1160	0.0207
2,4-D	0.4018	0.5122	0.0696	0.0124
2,4-DP	0.2678	0.3414	0.0464	0.0083
DALAPON	1.6740	2.1340	0.2900	0.0517
DICAMBA	0.3348	0.4268	0.0580	0.0103
FOSAMINE	2.0088	2.5608	0.3480	0.0620
GLYPHOSATE	0.8370	1.0670	0.1450	0.0258
HEXAZINONE	0.5022	0.6402	0.0870	0.0155
PICLORAM	0.0402	0.0512	0.0070	0.0012
SIMAZINE	0.8370	1.0670	0.1450	0.0258
TEBUTHIURON	1.0044	1.2804	0.1740	0.0310
TRICLOPYR	1.3392	1.7072	0.2320	0.0413

Table B-3
Doses to Backpack Sprayers (mg/kg) Small Backpack, 6.0 Acres, Routine-Realistic Case

HERBICIDE	DOSE
AMITROLE	0.0033
ASULAM	0.1978
ATRAZINE	0.4946
BROMACIL	0.6595
2,4-D	0.1978
2,4-DP	0.2110
DALAPON	0.6595
DICAMBA	0.0412
DIURON	0.6595
FOSAMINE	0.4946
GLYPHOSATE	0.2473
HEXAZINONE	0.1846
PICLORAM	0.0079
SIMAZINE	0.3297
TEBUTHIURON	0.2473
TRICLOPYR	0.3297

Table B-4
Doses to Backpack Sprayers (mg/kg) Large Backpack, 60 Acres, Routine-Worst Case

HERBICIDE	DOSE
AMITROLE	0.0310
ASULAM	2.0693
ATRAZINE	2.4782
BROMACIL	6.1955
2,4-D	1.4869
2,4-DP	1.7050
DALAPON	7.4346
DICAMBA	1.2391
DIURON	3.7173
FOSAMINE	7.1248
GLYPHOSATE	3.0978
HEXAZINONE	1.8587
PICLORAM	0.1190
SIMAZINE	2.8499
TEBUTHIURON	3.7173
TRICLOPYR	4.9564

Table B-5
Doses to Workers (mg/kg) Small Right of Way, Routine-Realistic Case

HERBICIDE	APPLICATOR	MIX/LOADER	APPL/MIX/LOADER
AMITROLE	0.0001	0.0001	0.0001
ASULAM	0.0082	0.0084	0.0116
ATRAZINE	0.0103	0.0105	0.0145
BROMACIL	0.0137	0.0140	0.0193
2,4-D	0.0051	0.0052	0.0072
2,4-DP	0.0055	0.0056	0.0077
DALAPON	0.0137	0.0140	0.0193
DICAMBA	0.0017	0.0017	0.0024
DIURON	0.0137	0.0140	0.0193
FOSAMINE	0.0137	0.0140	0.0193
GLYPHOSATE	0.0069	0.0070	0.0096
HEXAZINONE	0.0086	0.0087	0.0120
PICLORAM	0.0002	0.0002	0.0002
SIMAZINE	0.0069	0.0070	0.0096
TEBUTHIURON	0.0075	0.0077	0.0106
TRICLOPYR	0.0069	0.0070	0.0096

Table B-6
Doses to Workers (mg/kg) Large Right of Way, Routine-Worst Case

HERBICIDE	APPLICATOR	MIX/LOADER	APPL/MIX/LOADER
AMITROLE	0.0042	0.0024	0.0029
ASULAM	0.2652	0.1530	0.1787
ATRAZINE	0.4509	0.2601	0.3038
BROMACIL	0.5305	0.3060	0.3574
2,4-D	0.1305	0.0753	0.0879
2,4-DP	0.1698	0.0979	0.1144
DALAPON	0.5305	0.3060	0.3574
DICAMBA	0.0955	0.0551	0.0643
DIURON	0.8488	0.4896	0.5719
FOSAMINE	0.5676	0.3274	0.3824
GLYPHOSATE	0.2652	0.1530	0.1787
HEXAZINONE	0.3183	0.1836	0.2145
PICLORAM	0.0051	0.0029	0.0034
SIMAZINE	0.2440	0.1408	0.1644
TEBUTHIURON	0.2440	0.1408	0.1644
TRICLOPYR	0.4244	0.2448	0.2859

Table B-7
Doses to Workers (mg/kg) Hand Application to Small Site, Routine Realistic

HERBICIDE	HACK & SQUIRT	INJECTION BAR
AMITROLE	0.00056	0.00021
BROMACIL	0.11134	0.04235
2,4-D	0.06680	0.02541
2,4-DP	0.10689	0.04066
DICAMBA	0.05567	0.02118
DIURON	0.11134	0.04235
FOSAMINE	0.11134	0.04235
PICLORAM	0.00267	0.00102
TRICLOPYR	0.11134	0.04235

Table B-8
Doses to Workers (mg/kg) Hand Application to Large Site, Routine-Worst Case

HERBICIDE	HACK & SQUIRT	INJECTION BAR
AMITROLE	0.00631	0.00169
BROMACIL	1.26170	0.33728
2,4-D	0.75702	0.20237
2,4-DP	1.21123	0.32379
DICAMBA	0.63085	0.16864
DIURON	1.26170	0.33728
FOSAMINE	1.26170	0.33728
PICLORAM	0.03028	0.00809
TRICLOPYR	1.26170	0.33728

Table B-9
Doses in micrograms/kg by Exposure Type: Routine-Realistic Aerial, 40 Acres by Helicopter

HERBICIDE	SPRAY DRIFT DERMAL	VEGETATION CONTACT HIKER	VEGETATION CONTACT PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	0.000	0.000	0.032	1.884	1.079	2.158	0.146	0.489	0.754
ASULAM	0.019	0.000	3.894	2.261	1.295	2.589	0.185	0.660	0.904
ATRAZINE	0.030	0.000	6.084	3.532	2.023	4.045	0.289	1.031	7.064
2,4-D	0.012	0.000	2.434	2.355	1.348	2.697	0.188	0.656	0.942
2,4-DP	0.010	0.000	2.077	1.884	1.079	2.158	0.151	0.528	0.754
DALAPON	0.032	0.000	6.490	3.768	2.158	4.315	0.308	1.100	1.507
DICAMBA	0.004	0.000	0.811	0.942	0.539	1.079	0.075	0.259	0.377
FOSAMINE	0.024	0.000	4.867	2.826	1.618	3.236	0.231	0.825	1.130
GLYPHOSATE	0.016	0.000	3.245	1.884	1.079	2.158	0.154	0.550	0.754
HEXAZINONE	0.020	0.000	4.056	2.355	1.348	2.697	0.192	0.687	0.942
PICLORAM	0.000	0.000	0.078	0.942	0.539	1.079	0.073	0.245	0.377
SIMAZINE	0.032	0.000	6.490	3.768	2.158	4.315	0.308	1.100	1.507
TEBUTHIURON	0.008	0.000	1.622	0.942	0.539	1.079	0.077	0.275	3.768
TRICLOPYR	0.016	0.000	3.245	1.884	1.079	2.158	0.154	0.550	0.754

Table B-10
Doses in micrograms/kg for Example People[1] for Routine-Realistic Aerial, 40 Acres by Helicopter

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	1.884	2.995	2.518	2.637	4.041
ASULAM	2.280	7.468	3.125	3.184	4.869
ATRAZINE	3.563	11.669	4.882	10.627	7.608
2,4-D	2.367	6.149	3.212	3.309	5.064
2,4-DP	1.894	5.049	2.573	2.648	4.052
DALAPON	3.800	12.447	5.208	5.307	8.115
DICAMBA	0.946	2.296	1.280	1.323	2.025
FOSAMINE	2.850	9.335	3.906	3.980	6.086
GLYPHOSATE	1.900	6.223	2.604	2.654	4.058
HEXAZINONE	2.375	7.779	3.255	3.317	5.072
PICLORAM	0.942	1.560	1.261	1.319	2.021
SIMAZINE	3.800	12.447	5.208	5.307	8.115
TEBUTHIURON	0.950	3.112	1.302	4.718	2.029
TRICLOPYR	1.900	6.223	2.604	2.654	4.058

[1]All of these people receive multiple exposures as shown in Table 4-6.

Table B-11
Doses in micrograms/kg by Exposure Type for Large Aerial, 400 Acres by Fixed Wing, Routine-Worst Case

HERBICIDE	SPRAY DRIFT DERMAL	VEGETATION CONTACT HIKER	VEGETATION CONTACT PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	0.170	0.002	0.438	12.681	10.423	20.846	1.522	6.274	5.072
ASULAM	14.180	0.203	36.553	10.588	8.703	17.406	1.362	5.930	4.235
ATRAZINE	16.981	0.244	43.776	12.681	10.423	20.846	1.631	7.102	25.362
2,4-D	10.189	0.146	26.266	12.681	10.423	20.846	1.587	6.767	5.072
2,4-DP	6.793	0.097	17.510	7.926	6.514	13.028	0.994	4.251	3.170
DALAPON	42.454	0.609	109.440	31.702	26.057	52.114	4.077	17.754	12.681
DICAMBA	8.491	0.122	21.888	12.681	10.423	20.846	1.576	6.684	5.072
FOSAMINE	50.944	0.731	131.328	38.042	31.268	62.537	4.892	21.305	15.217
GLYPHOSATE	21.227	0.305	54.720	15.851	13.028	26.057	2.039	8.877	6.340
HEXAZINONE	12.736	0.183	32.832	9.511	7.817	15.634	1.223	5.326	3.804
PICLORAM	1.019	0.015	2.627	15.851	13.028	26.057	1.907	7.883	6.340
SIMAZINE	21.227	0.305	54.720	15.851	13.028	26.057	2.039	8.877	6.340
TEBUTHIURON	25.472	0.365	65.664	19.021	15.634	31.268	2.446	10.653	76.085
TRICLOPYR	33.963	0.487	87.552	25.362	20.846	41.691	3.262	14.203	10.145

Table B-12
Doses in micrograms/kg for Example People[1] for Large Aerial, 400 Acres by Fixed Wing, Routine-Worst Case

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	12.853	23.711	20.649	17.925	33.699
ASULAM	24.971	70.024	32.263	29.207	42.377
ATRAZINE	29.906	83.861	38.638	55.267	50.751
2,4-D	23.016	59.558	31.370	28.088	43.861
2,4-DP	14.816	38.743	20.061	17.986	27.844
DALAPON	74.765	209.653	96.596	87.445	126.879
DICAMBA	21.293	53.482	29.553	26.366	42.139
FOSAMINE	89.718	251.583	115.915	104.935	152.254
GLYPHOSATE	37.382	104.826	48.298	43.723	63.439
HEXAZINONE	22.429	62.896	28.979	26.234	38.064
PICLORAM	16.885	32.525	26.674	23.225	42.941
SIMAZINE	37.382	104.826	48.298	43.723	63.439
TEBUTHIURON	44.859	125.792	57.958	120.944	76.127
TRICLOPYR	59.812	167.722	77.277	69.956	101.503

[1]All of these people receive multiple exposures as shown in Table 4-6.

Table B-13
Doses in micrograms/kg by Exposure Type for Small Backpack, 6.0 Acres, Routine-Realistic Case

HERBICIDE	SPRAY DRIFT DERMAL	VEGETATION CONTACT HIKER	VEGETATION CONTACT PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	0.002	0.000	0.007	0.166	0.306	0.612	0.038	0.109	0.066
ASULAM	0.107	0.002	0.423	0.100	0.184	0.367	0.024	0.073	0.040
ATRAZINE	0.267	0.004	1.057	0.249	0.459	0.918	0.060	0.184	0.498
BROMACIL	0.356	0.005	1.409	0.332	0.612	1.224	0.080	0.245	0.133
2,4-D	0.107	0.002	0.423	0.166	0.306	0.612	0.039	0.117	0.066
2,4-DP	0.114	0.002	0.451	0.166	0.306	0.612	0.039	0.118	0.066
DALAPON	0.356	0.005	1.409	0.332	0.612	1.224	0.080	0.245	0.133
DICAMBA	0.022	0.000	0.088	0.041	0.076	0.153	0.010	0.029	0.017
DIURON	0.356	0.005	1.409	0.332	0.612	1.224	0.080	0.245	2.654
FOSAMINE	0.267	0.004	1.057	0.249	0.459	0.918	0.060	0.184	0.100
GLYPHOSATE	0.134	0.002	0.528	0.124	0.229	0.459	0.030	0.092	0.050
HEXAZINONE	0.100	0.001	0.395	0.093	0.171	0.343	0.022	0.069	0.037
PICLORAM	0.004	0.000	0.017	0.083	0.153	0.306	0.019	0.055	0.033
SIMAZINE	0.178	0.003	0.705	0.166	0.306	0.612	0.040	0.122	0.066
TEBUTHIURON	0.134	0.002	0.528	0.124	0.229	0.459	0.030	0.092	0.498
TRICLOPYR	0.178	0.003	0.705	0.166	0.306	0.612	0.040	0.122	0.066

Table B-14
Doses in micrograms/kg for Example People[1] for Small Backpack, 6.0 Acres, Routine-Realistic Case

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	0.168	0.481	0.315	0.234	0.780
ASULAM	0.208	0.813	0.305	0.248	0.575
ATRAZINE	0.520	2.032	0.763	1.017	1.438
BROMACIL	0.693	2.709	1.017	0.825	1.917
2,4-D	0.274	1.001	0.430	0.341	0.886
2,4-DP	0.281	1.037	0.438	0.348	0.893
DALAPON	0.693	2.709	1.017	0.825	1.917
DICAMBA	0.064	0.228	0.103	0.081	0.217
DIURON	0.693	2.709	1.017	3.346	1.917
FOSAMINE	0.520	2.032	0.763	0.619	1.438
GLYPHOSATE	0.260	1.016	0.381	0.310	0.719
HEXAZINONE	0.194	0.759	0.285	0.231	0.537
PICLORAM	0.087	0.257	0.161	0.120	0.393
SIMAZINE	0.346	1.354	0.509	0.413	0.958
TEBUTHIURON	0.260	1.016	0.381	0.757	0.719
TRICLOPYR	0.346	1.354	0.509	0.413	0.958

[1]All of these people receive multiple exposures as shown in Table 4-6.

Table B-15
Doses in micrograms/kg by Exposure Type for Large Backpack, 60 Acres, Routine-Worst Case

HERBICIDE	SPRAY DRIFT DERMAL	VEGETATION CONTACT HIKER	VEGETATION CONTACT PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	0.009	0.000	0.022	0.477	0.922	1.843	0.116	0.339	0.191
ASULAM	0.572	0.008	1.475	0.319	0.616	1.231	0.081	0.255	0.128
ATRAZINE	0.685	0.010	1.766	0.382	0.737	1.475	0.097	0.305	0.764
BROMACIL	1.713	0.025	4.416	0.955	1.843	3.687	0.242	0.762	0.382
2,4-D	0.411	0.006	1.060	0.382	0.737	1.475	0.095	0.291	0.153
2,4-DP	0.471	0.007	1.215	0.411	0.793	1.585	0.102	0.315	0.164
DALAPON	2.056	0.029	5.299	1.146	2.212	4.424	0.290	0.915	0.458
DICAMBA	0.343	0.005	0.883	0.382	0.737	1.475	0.095	0.288	0.153
DIURON	1.028	0.015	2.650	0.573	1.106	2.212	0.145	0.457	4.584
FOSAMINE	1.970	0.028	5.078	1.098	2.120	4.240	0.278	0.876	0.439
GLYPHOSATE	0.857	0.012	2.208	0.477	0.922	1.843	0.121	0.381	0.191
HEXAZINONE	0.514	0.007	1.325	0.286	0.553	1.106	0.073	0.229	0.115
PICLORAM	0.033	0.000	0.085	0.382	0.737	1.475	0.093	0.273	0.153
SIMAZINE	0.788	0.011	2.031	0.439	0.848	1.696	0.111	0.351	0.176
TEBUTHIURON	1.028	0.015	2.650	0.573	1.106	2.212	0.145	0.457	2.292
TRICLOPYR	1.370	0.020	3.533	0.764	1.475	2.949	0.194	0.610	0.306

Table B-16
Doses in micrograms/kg for Example People[1] for Large Backpack, 60 Acres, Routine-Worst Case

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	0.486	1.430	0.941	0.677	2.330
ASULAM	0.899	2.982	1.235	1.027	2.131
ATRAZINE	1.077	3.571	1.479	1.841	2.552
BROMACIL	2.693	8.927	3.697	3.075	6.379
2,4-D	0.799	2.590	1.185	0.952	2.274
2,4-DP	0.889	2.890	1.306	1.053	2.474
DALAPON	3.231	10.713	4.436	3.690	7.655
DICAMBA	0.730	2.345	1.112	0.882	2.204
DIURON	1.616	5.356	2.218	6.200	3.828
FOSAMINE	3.096	10.267	4.251	3.536	7.336
GLYPHOSATE	1.346	4.464	1.848	1.537	3.190
HEXAZINONE	0.808	2.678	1.109	0.922	1.914
PICLORAM	0.415	1.237	0.781	0.568	1.890
SIMAZINE	1.239	4.107	1.701	1.414	2.935
TEBUTHIURON	1.616	5.356	2.218	3.908	3.828
TRICLOPYR	2.154	7.142	2.957	2.460	5.103

[1] All of these people receive multiple exposures as shown in Table 4-6.

Table B-17
Doses in micrograms/kg by Exposure Type for Small Right of Way, Routine-Realistic Case

HERBICIDE	SPRAY DRIFT DERMAL	VEGETATION CONTACT HIKER	VEGETATION CONTACT PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	0.000	0.000	0.002	0.074	0.102	0.204	0.012	0.030	0.030
ASULAM	0.041	0.001	0.224	0.089	0.123	0.245	0.015	0.041	0.036
ATRAZINE	0.052	0.001	0.280	0.112	0.153	0.307	0.019	0.051	0.223
BROMACIL	0.069	0.001	0.373	0.149	0.204	0.409	0.025	0.068	0.060
2,4-D	0.026	0.000	0.140	0.093	0.128	0.256	0.016	0.041	0.037
2,4-DP	0.028	0.000	0.149	0.093	0.128	0.256	0.016	0.041	0.037
DALAPON	0.069	0.001	0.373	0.149	0.204	0.409	0.025	0.068	0.060
DICAMBA	0.009	0.000	0.047	0.037	0.051	0.102	0.006	0.016	0.015
DIURON	0.069	0.001	0.373	0.149	0.204	0.409	0.025	0.068	1.191
FOSAMINE	0.069	0.001	0.373	0.149	0.204	0.409	0.025	0.068	0.060
GLYPHOSATE	0.034	0.000	0.187	0.074	0.102	0.204	0.013	0.034	0.030
HEXAZINONE	0.043	0.001	0.233	0.093	0.128	0.256	0.016	0.042	0.037
PICLORAM	0.001	0.000	0.004	0.037	0.051	0.102	0.006	0.015	0.015
SIMAZINE	0.034	0.000	0.187	0.074	0.102	0.204	0.013	0.034	0.030
TEBUTHIURON	0.038	0.001	0.205	0.082	0.112	0.225	0.014	0.037	0.327
TRICLOPYR	0.034	0.000	0.187	0.074	0.102	0.204	0.013	0.034	0.030

Table B-18
Doses in micrograms/kg for Example People[1] for Small Right of Way, Routine-Realistic Case

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	0.075	0.179	0.117	0.105	0.279
ASULAM	0.131	0.477	0.187	0.167	0.377
ATRAZINE	0.164	0.597	0.234	0.387	0.471
BROMACIL	0.219	0.796	0.312	0.278	0.628
2,4-D	0.119	0.387	0.175	0.156	0.375
2,4-DP	0.121	0.398	0.177	0.158	0.377
DALAPON	0.219	0.796	0.312	0.278	0.628
DICAMBA	0.046	0.144	0.068	0.061	0.148
DIURON	0.219	0.796	0.312	1.409	0.628
FOSAMINE	0.219	0.796	0.312	0.278	0.628
GLYPHOSATE	0.109	0.398	0.156	0.139	0.314
HEXAZINONE	0.137	0.497	0.195	0.174	0.392
PICLORAM	0.038	0.094	0.059	0.053	0.140
SIMAZINE	0.109	0.398	0.156	0.139	0.314
TEBUTHIURON	0.120	0.438	0.172	0.448	0.345
TRICLOPYR	0.109	0.398	0.156	0.139	0.314

[1]All of these people receive multiple exposures as shown in Table 4-6.

Table B-19
Doses in micrograms/kg by Exposure Type for Large Right of Way, Routine-Worst Case

HERBICIDE	SPRAY DRIFT DERMAL	VEGETATION CONTACT HIKER	VEGETATION CONTACT PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	0.005	0.000	0.012	0.398	0.620	1.240	0.075	0.197	0.159
ASULAM	0.300	0.004	0.773	0.249	0.388	0.775	0.049	0.138	0.100
ATRAZINE	0.510	0.007	1.314	0.423	0.659	1.318	0.083	0.234	0.846
BROMACIL	0.600	0.009	1.546	0.498	0.775	1.550	0.098	0.275	0.199
2,4-D	0.147	0.002	0.380	0.204	0.318	0.636	0.040	0.108	0.082
2,4-DP	0.192	0.003	0.495	0.249	0.388	0.775	0.048	0.132	0.100
DALAPON	0.600	0.009	1.546	0.498	0.775	1.550	0.098	0.275	0.199
DICAMBA	0.108	0.002	0.278	0.179	0.279	0.558	0.035	0.094	0.072
DIURON	0.959	0.014	2.473	0.796	1.240	2.481	0.157	0.441	6.372
FOSAMINE	0.642	0.009	1.654	0.533	0.829	1.659	0.105	0.295	0.213
GLYPHOSATE	0.300	0.004	0.773	0.249	0.388	0.775	0.049	0.138	0.100
HEXAZINONE	0.360	0.005	0.927	0.299	0.465	0.930	0.059	0.165	0.119
PICLORAM	0.006	0.000	0.015	0.100	0.155	0.310	0.019	0.049	0.040
SIMAZINE	0.276	0.004	0.711	0.229	0.357	0.713	0.045	0.127	0.092
TEBUTHIURON	0.276	0.004	0.711	0.229	0.357	0.713	0.045	0.127	0.916
TRICLOPYR	0.480	0.007	1.236	0.398	0.620	1.240	0.078	0.220	0.159

Table B-20
Doses in micrograms/kg for Example People[1] for Large Right of Way, Routine-Worst Case

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	0.403	1.036	0.675	0.562	1.643
ASULAM	0.553	1.709	0.740	0.653	1.328
ATRAZINE	0.940	2.905	1.258	1.786	2.258
BROMACIL	1.106	3.418	1.479	1.305	2.656
2,4-D	0.354	1.050	0.501	0.435	0.989
2,4-DP	0.444	1.323	0.624	0.543	1.219
DALAPON	1.106	3.418	1.479	1.305	2.656
DICAMBA	0.289	0.844	0.417	0.360	0.847
DIURON	1.770	5.469	2.367	8.141	4.250
FOSAMINE	1.183	3.657	1.583	1.396	2.842
GLYPHOSATE	0.553	1.709	0.740	0.653	1.328
HEXAZINONE	0.664	2.051	0.888	0.783	1.594
PICLORAM	0.105	0.275	0.174	0.145	0.415
SIMAZINE	0.509	1.572	0.681	0.600	1.222
TEBUTHIURON	0.509	1.572	0.681	1.425	1.222
TRICLOPYR	0.885	2.735	1.184	1.044	2.125

[1]All of these people receive multiple exposures as shown in Table 4-6.

Table B-21
Doses in micrograms/kg from Items Receiving the Full Per Acre Application Rate by Exposure Type
Accidental-Worst Case

HERBICIDE	DIRECT DERMAL	REENTRY HIKER	REENTRY PICKER	DRINK WATER	EATING BERRIES	EATING VEGS.	EATING DEER	EATING BIRD	EATING FISH
AMITROLE	3.	0.	9.	117.	93.	194.	19.	116.	47.
ASULAM	209.	3.	538.	73.	58.	121.	13.	83.	29.
ATRAZINE	355.	5.	914.	125.	99.	206.	22.	141.	249.
BROMACIL	417.	6.	1075.	147.	116.	242.	26.	165.	59.
2,4-D	103.	1.	264.	60.	48.	99.	10.	64.	24.
2,4-DP	133.	2.	344.	73.	58.	121.	13.	79.	29.
DALAPON	417.	6.	1075.	147.	116.	242.	26.	165.	59.
DICAMBA	83.	1.	215.	59.	47.	97.	10.	62.	23.
DIURON	667.	10.	1720.	235.	186.	387.	42.	265.	1878.
FOSAMINE	501.	7.	1290.	176.	140.	290.	31.	199.	70.
GLYPHOSATE	209.	3.	538.	73.	58.	121.	13.	83.	29.
HEXAZINONE	250.	4.	645.	88.	70.	145.	16.	99.	35.
PICLORAM	10.	0.	26.	73.	58.	121.	12.	73.	29.
SIMAZINE	209.	3.	538.	73.	58.	121.	13.	83.	29.
TEBUTHIURON	250.	4.	645.	88.	70.	145.	16.	99.	352.
TRICLOPYR	334.	5.	860.	117.	93.	194.	21.	132.	47.

Table B-22
Doses in micrograms/kg for Example People[1] for Accidental-Worst Case Spraying

HERBICIDE	HIKER	BERRY PICKER	HUNTER	FISHERMAN	NEARBY RESIDENT
AMITROLE	121.	222.	256.	168.	314.
ASULAM	285.	878.	381.	314.	406.
ATRAZINE	484.	1492.	647.	734.	690.
BROMACIL	570.	1755.	761.	628.	812.
2,4-D	164.	475.	239.	188.	263.
2,4-DP	209.	609.	300.	238.	330.
DALAPON	570.	1755.	761.	628.	812.
DICAMBA	143.	404.	215.	167.	240.
DIURON	912.	2809.	1218.	2790.	1299.
FOSAMINE	684.	2107.	914.	754.	974.
GLYPHOSATE	285.	878.	381.	314.	406.
HEXAZINONE	342.	1053.	457.	377.	487.
PICLORAM	84.	167.	168.	113.	204.
SIMAZINE	285.	878.	381.	314.	406.
TEBUTHIURON	342.	1053.	457.	694.	487.
TRICLOPYR	456.	1404.	609.	503.	649.

[1]All of these people receive multiple exposures as shown in Table 4-6.

DOSES TO WORKERS AND THE PUBLIC FROM SPILLS

Table B-23
Doses from Herbicide Spills (mg/kg)

HERBICIDE	SPILL OF ONE PINT CONCENTRATE ON SKIN	SPILL OF ONE PINT TANK MIX ON SKIN	HELICOPTER[1] DUMP INTO POND	HELICOPTER[1] DUMP INTO RESERVOIR	TRUCK[1] SPILL INTO POND	TRUCK[1] SPILL INTO RESERVOIR
AMITROLE	1.20	0.24	0.0737	0.0023	0.7365	0.0230
ASULAM	240.00	20.04	0.0615	0.0019	0.6150	0.0192
ATRAZINE	240.00	24.00	0.0737	0.0023	0.7365	0.0230
BROMACIL	240.00	12.00	-----	-----	0.3683	0.0115
2,4-D	144.00	14.40	0.0737	0.0023	0.7365	0.0230
2,4-DP	230.40	9.60	0.0460	0.0014	0.4603	0.0144
DALAPON	---	60.00	0.1841	0.0058	1.8413	0.0575
DICAMBA	120.00	12.00	0.0737	0.0023	0.7365	0.0230
DIURON	240.00	19.20	-----	-----	0.5892	0.0184
FOSAMINE	240.00	72.00	0.2210	0.0069	2.2095	0.0690
GLYPHOSATE	180.00	30.00	0.0921	0.0029	0.9206	0.0288
HEXAZINONE	120.00	18.00	0.0552	0.0017	0.5524	0.0173
PICLORAM	5.76	1.44	0.0921	0.0029	0.9206	0.0288
SIMAZINE	240.00	30.00	0.0921	0.0029	0.9206	0.0288
TEBUTHIURON	---	36.00	0.1105	0.0035	1.1048	0.0345
TRICLOPYR	240.00	48.00	0.1473	0.0046	1.4730	0.0460

[1]Assuming 1 liter of water drunk per day.

LIFETIME DOSES IN ROUTINE OPERATIONS

Table B-24
Lifetime Doses for Exposed Workers (mg/kg/day)

	Exposures per Lifetime	Average Daily Dose Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
Realistic Number of Exposures								
Pilot	30	5.73E-05	4.45E-05	8.68E-05	----	3.44E-06	8.43E-07	9.41E-05
Mixer/Loader	30	7.84E-05	6.13E-05	1.19E-04	----	4.55E-06	1.15E-06	1.27E-04
Supervisor	30	9.24E-06	7.12E-06	1.39E-05	----	5.74E-07	1.37E-07	1.54E-05
Observer	30	1.82E-06	1.42E-06	2.76E-06	----	1.08E-07	2.67E-08	2.97E-06
Backpack	50	5.13E-04	5.59E-04	5.70E-04	1.83E-03	2.64E-05	9.16E-06	7.63E-04
R-O-W Sprayer	45	2.01E-05	2.41E-05	3.71E-05	6.97E-05	7.24E-07	4.88E-07	3.48E-05
R-O-W Mix/L	45	1.54E-05	1.80E-05	2.75E-05	5.03E-05	5.39E-07	3.32E-07	2.52E-05
R-O-W AP/M/L	45	1.98E-05	2.30E-05	3.51E-05	6.37E-05	6.89E-07	4.13E-07	3.19E-05
Hack & Squirt	70	2.78E-04	4.44E-04	----	4.63E-04	1.11E-05	2.31E-06	----
Injection Bar	70	9.39E-05	1.50E-04	----	1.56E-04	3.75E-06	7.82E-07	----
Worst Case Number of Exposures								
Pilot	288	5.50E-04	4.27E-04	8.33E-04	----	3.30E-05	8.09E-06	9.03E-04
Mixer/Loader	288	7.53E-04	5.88E-04	1.14E-03	----	4.37E-05	1.10E-05	1.22E-03
Supervisor	288	8.87E-05	6.84E-05	1.34E-04	----	5.51E-06	1.31E-06	1.48E-04
Observer	288	1.75E-05	1.36E-05	2.65E-05	----	1.03E-06	2.56E-07	2.86E-05
Backpack	440	4.52E-03	4.92E-03	5.02E-03	1.61E-02	2.32E-04	8.06E-05	6.71E-03
R-O-W Sprayer	416	1.86E-04	2.23E-04	3.43E-04	6.44E-04	6.69E-06	4.52E-06	3.22E-04
R-O-W Mix/L	416	1.42E-04	1.66E-04	2.54E-04	4.65E-04	4.98E-06	3.07E-06	2.33E-04
R-O-W AP/M/L	416	1.83E-04	2.12E-04	3.24E-04	5.89E-04	6.37E-06	3.82E-06	2.95E-04
Hack & Squirt	480	1.90E-03	3.05E-03	----	3.17E-03	7.61E-05	1.59E-05	----
Injection Bar	480	6.44E-04	1.03E-03	----	1.07E-03	2.57E-05	5.36E-06	----

Table B-25
Lifetime Doses for Exposed Public (mg/kg/day) Realistic Aerial, 40 Acres by Helicopter

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray Vegetation Contact	1	4.71E-10	4.02E-10	7.53E-10	----	1.51E-11	6.28E-12	6.28E-10
Hiker	1	6.76E-12	5.77E-12	1.08E-11	----	2.16E-13	9.01E-14	9.01E-12
Picker	1	9.52E-08	8.13E-08	1.52E-07	----	3.05E-09	1.27E-09	1.27E-07
Drinking Water	1	9.22E-08	7.37E-08	8.85E-08	----	3.69E-08	7.37E-08	7.37E-08
Eating Berries	1	5.28E-08	4.22E-08	5.07E-08	----	2.11E-08	4.22E-08	4.22E-08
Eating Vegets.	1	1.06E-07	8.44E-08	1.01E-07	----	4.22E-08	8.44E-08	8.44E-08
Eating Deer	1	7.37E-09	5.91E-09	7.23E-09	----	2.86E-09	5.71E-09	6.03E-09
Eating Fish	1	3.69E-08	2.95E-08	3.54E-08	----	1.47E-08	2.95E-08	2.95E-08
Combined Routes of Exposure								
Hiker	1	9.26E-08	7.41E-08	8.92E-08	----	3.69E-08	7.37E-08	7.44E-08
Berry Picker	1	2.41E-07	1.98E-07	2.92E-07	----	6.10E-08	1.17E-07	2.44E-07
Hunter	1	1.26E-07	1.01E-07	1.22E-07	----	4.93E-08	9.86E-08	1.02E-07
Fisherman	1	1.30E-07	1.04E-07	1.25E-07	----	5.16E-08	1.03E-07	1.04E-07
Resident	1	1.98E-07	1.59E-07	1.91E-07	----	7.91E-08	1.58E-07	1.59E-07
For 30 Exposures								
Dermal, Spray Vegetation Contact	30	1.41E-08	1.21E-08	2.26E-08	----	4.52E-10	1.88E-10	1.88E-08
Hiker	30	2.03E-10	1.73E-10	3.24E-10	----	6.49E-12	2.70E-12	2.70E-10
Picker	30	2.86E-06	2.44E-06	4.57E-06	----	9.14E-08	3.81E-08	3.81E-06
Drinking Water	30	2.76E-06	2.21E-06	2.65E-06	----	1.11E-06	2.21E-06	2.21E-06
Eating Berries	30	1.58E-06	1.27E-06	1.52E-06	----	6.33E-07	1.27E-06	1.27E-06
Eating Vegets.	30	3.17E-06	2.53E-06	3.04E-06	----	1.27E-06	2.53E-06	2.53E-06
Eating Deer	30	2.21E-07	1.77E-07	2.17E-07	----	8.58E-08	1.71E-07	1.81E-07
Eating Fish	30	1.11E-06	8.85E-07	1.06E-06	----	4.42E-07	8.85E-07	8.85E-07
Combined Routes of Exposure								
Hiker	30	2.78E-06	2.22E-06	2.68E-06	----	1.11E-06	2.21E-06	2.23E-06
Berry Picker	30	7.22E-06	5.93E-06	8.77E-06	----	1.83E-06	3.52E-06	7.31E-06
Hunter	30	3.77E-06	3.02E-06	3.67E-06	----	1.48E-06	2.96E-06	3.06E-06
Fisherman	30	3.89E-06	3.11E-06	3.74E-06	----	1.55E-06	3.10E-06	3.12E-06
Resident	30	5.95E-06	4.76E-06	5.72E-06	----	2.37E-06	4.75E-06	4.76E-06

Table B-26
Lifetime Doses for Exposed Public (mg/kg/day) Large Aerial, 400 Acres by Fixed Wing, Worst Case

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray	1	3.99E-07	2.66E-07	5.55E-07	----	3.99E-08	6.65E-09	8.31E-07
Vegetation Contact								
Hiker	1	5.72E-09	3.81E-09	7.96E-09	----	5.72E-10	9.54E-11	1.19E-08
Picker	1	1.03E-06	6.85E-07	1.43E-06	----	1.03E-07	1.71E-08	2.14E-06
Drinking Water	1	4.96E-07	3.10E-07	4.14E-07	----	6.20E-07	4.96E-07	6.20E-07
Eating Berries	1	4.08E-07	2.55E-07	3.41E-07	----	5.10E-07	4.08E-07	5.10E-07
Eating Vegets.	1	8.16E-07	5.10E-07	6.81E-07	----	1.02E-06	8.16E-07	1.02E-06
Eating Deer	1	6.21E-08	3.89E-08	5.33E-08	----	7.46E-08	5.96E-08	7.98E-08
Eating Fish	1	1.99E-07	1.24E-07	1.66E-07	----	2.48E-07	1.99E-07	2.48E-07
Combined Routes of Exposure								
Hiker	1	9.01E-07	5.80E-07	9.77E-07	----	6.61E-07	5.03E-07	1.46E-06
Berry Picker	1	2.33E-06	1.52E-06	2.74E-06	----	1.27E-06	9.28E-07	4.10E-06
Hunter	1	1.23E-06	7.85E-07	1.26E-06	----	1.04E-06	8.08E-07	1.89E-06
Fisherman	1	1.10E-06	7.04E-07	1.14E-06	----	9.09E-07	7.02E-07	1.71E-06
Resident	1	1.72E-06	1.09E-06	1.66E-06	----	1.68E-06	1.32E-06	2.48E-06
For 30 Exposures								
Dermal, Spray	30	1.20E-05	7.98E-06	1.66E-05	----	1.20E-06	1.99E-07	2.49E-05
Vegetation Contact								
Hiker	30	1.72E-07	1.14E-07	2.39E-07	----	1.72E-08	2.86E-09	3.58E-07
Picker	30	3.08E-05	2.06E-05	4.29E-05	----	3.08E-06	5.14E-07	6.43E-05
Drinking Water	30	1.49E-05	9.31E-06	1.24E-05	----	1.86E-05	1.49E-05	1.86E-05
Eating Berries	30	1.22E-05	7.65E-06	1.02E-05	----	1.53E-05	1.22E-05	1.53E-05
Eating Vegets.	30	2.45E-05	1.53E-05	2.04E-05	----	3.06E-05	2.45E-05	3.06E-05
Eating Deer	30	1.86E-06	1.17E-06	1.60E-06	----	2.24E-06	1.79E-06	2.39E-06
Eating Fish	30	5.96E-06	3.72E-06	4.97E-06	----	7.44E-06	5.96E-06	7.44E-06
Combined Routes of Exposure								
Hiker	30	2.70E-05	1.74E-05	2.93E-05	----	1.98E-05	1.51E-05	4.39E-05
Berry Picker	30	6.99E-05	4.55E-05	8.22E-05	----	3.82E-05	2.78E-05	1.23E-04
Hunter	30	3.68E-05	2.36E-05	3.79E-05	----	3.13E-05	2.42E-05	5.67E-05
Fisherman	30	3.30E-05	2.11E-05	3.43E-05	----	2.73E-05	2.10E-05	5.13E-05
Resident	30	5.15E-05	3.27E-05	4.98E-05	----	5.04E-05	3.96E-05	7.45E-05

Table B-27
Lifetime Doses for Exposed Public (mg/kg/day) Small Backpack, 6.0 Acres, Reaslitic Case

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray Vegetation Contact	1	4.18E-09	4.46E-09	4.18E-09	1.39E-08	1.67E-10	6.97E-11	5.23E-09
Hiker	1	6.00E-11	6.40E-11	6.00E-11	2.00E-10	2.40E-12	1.00E-12	7.50E-11
Picker	1	1.65E-08	1.77E-08	1.65E-08	5.52E-08	6.62E-10	2.76E-10	2.07E-08
Drinking Water	1	6.49E-09	6.49E-09	3.89E-09	1.30E-08	3.25E-09	6.49E-09	4.87E-09
Eating Berries	1	1.20E-08	1.20E-08	7.19E-09	2.40E-08	5.99E-09	1.20E-08	8.98E-09
Eating Vegets.	1	2.40E-08	2.40E-08	1.44E-08	4.79E-08	1.20E-08	2.40E-08	1.80E-08
Eating Deer	1	1.53E-09	1.53E-09	9.35E-10	3.12E-09	7.46E-10	1.49E-09	1.17E-09
Eating Fish	1	2.60E-09	2.60E-09	1.56E-09	5.19E-09	1.30E-09	2.60E-09	1.95E-09
Combined Routes of Exposure								
Hiker	1	1.07E-08	1.10E-08	8.13E-09	2.71E-08	3.42E-09	6.56E-09	1.02E-08
Berry Picker	1	3.92E-08	4.06E-08	3.18E-08	1.06E-07	1.01E-08	1.88E-08	3.98E-08
Hunter	1	1.68E-08	1.71E-08	1.19E-08	3.98E-08	6.31E-09	1.23E-08	1.49E-08
Fisherman	1	1.33E-08	1.36E-08	9.69E-09	3.23E-08	4.71E-09	9.16E-09	1.21E-08
Resident	1	3.47E-08	3.50E-08	2.25E-08	7.50E-08	1.54E-08	3.05E-08	2.81E-08
For 30 Exposures								
Dermal, Spray Vegetation Contact	30	1.25E-07	1.34E-07	1.25E-07	4.18E-07	5.02E-09	2.09E-09	1.57E-07
Hiker	30	1.80E-09	1.92E-09	1.80E-09	6.00E-09	7.20E-11	3.00E-11	2.25E-09
Picker	30	4.96E-07	5.30E-07	4.96E-07	1.65E-06	1.99E-08	8.27E-09	6.21E-07
Drinking Water	30	1.95E-07	1.95E-07	1.17E-07	3.89E-07	9.74E-08	1.95E-07	1.46E-07
Eating Berries	30	3.59E-07	3.59E-07	2.16E-07	7.19E-07	1.80E-07	3.59E-07	2.69E-07
Eating Vegets.	30	7.19E-07	7.19E-07	4.31E-07	1.44E-06	3.59E-07	7.19E-07	5.39E-07
Eating Deer	30	4.59E-08	4.60E-08	2.81E-08	9.35E-08	2.24E-08	4.47E-08	3.51E-08
Eating Fish	30	7.79E-08	7.79E-08	4.67E-08	1.56E-07	3.89E-08	7.79E-08	5.84E-08
Combined Routes of Exposure								
Hiker	30	3.22E-07	3.30E-07	2.44E-07	8.13E-07	1.02E-07	1.97E-07	3.05E-07
Berry Picker	30	1.18E-06	1.22E-06	9.54E-07	3.18E-06	3.02E-07	5.64E-07	1.19E-06
Hunter	30	5.05E-07	5.14E-07	3.58E-07	1.19E-06	1.89E-07	3.70E-07	4.48E-07
Fisherman	30	4.00E-07	4.08E-07	2.91E-07	9.69E-07	1.41E-07	2.75E-07	3.63E-07
Resident	30	1.04E-06	1.05E-06	6.75E-07	2.25E-06	4.62E-07	9.15E-07	8.44E-07

Table B-28
Lifetime Doses for Exposed Public (mg/kg/day) Large Backpack, 60 Acres, Worst Case

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray Vegetation Contact	1	1.61E-08	1.85E-08	2.24E-08	6.70E-08	1.29E-09	3.35E-10	3.35E-08
Hiker	1	2.31E-10	2.65E-10	3.21E-10	9.62E-10	1.85E-11	4.81E-12	4.81E-10
Picker	1	4.15E-08	4.76E-08	5.77E-08	1.73E-07	3.32E-09	8.64E-10	8.64E-08
Drinking Water	1	1.50E-08	1.61E-08	1.25E-08	3.74E-08	1.50E-08	1.87E-08	1.87E-08
Eating Berries	1	2.89E-08	3.10E-08	2.41E-08	7.21E-08	2.89E-08	3.61E-08	3.61E-08
Eating Vegets.	1	5.77E-08	6.20E-08	4.82E-08	1.44E-07	5.77E-08	7.21E-08	7.21E-08
Eating Deer	1	3.72E-09	4.01E-09	3.16E-09	9.47E-09	3.62E-09	4.52E-09	4.74E-09
Eating Fish	1	5.98E-09	6.43E-09	4.99E-09	1.50E-08	5.98E-09	7.48E-09	7.48E-09
Combined Routes of Exposure								
Hiker	1	3.13E-08	3.48E-08	3.52E-08	1.05E-07	1.63E-08	1.90E-08	5.27E-08
Berry Picker	1	1.01E-07	1.13E-07	1.17E-07	3.49E-07	4.84E-08	5.60E-08	1.75E-07
Hunter	1	4.64E-08	5.11E-08	4.83E-08	1.45E-07	3.06E-08	3.68E-08	7.23E-08
Fisherman	1	3.73E-08	4.12E-08	4.02E-08	1.20E-07	2.22E-08	2.65E-08	6.02E-08
Resident	1	8.90E-08	9.68E-08	8.34E-08	2.50E-07	7.40E-08	9.12E-08	1.25E-07
For 30 Exposures								
Dermal, Spray Vegetation Contact	30	4.83E-07	5.54E-07	6.72E-07	2.01E-06	3.86E-08	1.01E-08	1.01E-06
Hiker	30	6.93E-09	7.94E-09	9.64E-09	2.89E-08	5.54E-10	1.44E-10	1.44E-08
Picker	30	1.24E-06	1.43E-06	1.73E-06	5.19E-06	9.96E-08	2.59E-08	2.59E-06
Drinking Water	30	4.49E-07	4.82E-07	3.75E-07	1.12E-06	4.49E-07	5.61E-07	5.61E-07
Eating Berries	30	8.66E-07	9.31E-07	7.23E-07	2.16E-06	8.66E-07	1.08E-06	1.08E-06
Eating Vegets.	30	1.73E-06	1.86E-06	1.45E-06	4.33E-06	1.73E-06	2.16E-06	2.16E-06
Eating Deer	30	1.12E-07	1.20E-07	9.49E-08	2.84E-07	1.09E-07	1.36E-07	1.42E-07
Eating Fish	30	1.79E-07	1.93E-07	1.50E-07	4.49E-07	1.79E-07	2.24E-07	2.24E-07
Combined Routes of Exposure								
Hiker	30	9.38E-07	1.04E-06	1.06E-06	3.16E-06	4.88E-07	5.71E-07	1.58E-06
Berry Picker	30	3.04E-06	3.39E-06	3.50E-06	1.05E-05	1.45E-06	1.68E-06	5.24E-06
Hunter	30	1.39E-06	1.53E-06	1.45E-06	4.34E-06	9.17E-07	1.10E-06	2.17E-06
Fisherman	30	1.12E-06	1.24E-06	1.21E-06	3.61E-06	6.67E-07	7.95E-07	1.81E-06
Resident	30	2.67E-06	2.91E-06	2.50E-06	7.49E-06	2.22E-06	2.74E-06	3.75E-06

Table B-29
Lifetime Doses for Exposed Public (mg/kg/day) Small Right of Way, Realistic Case

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray Vegetation Contact	1	1.01E-09	1.08E-09	1.62E-09	2.70E-09	3.24E-11	1.35E-11	1.35E-09
Hiker	1	1.45E-11	1.55E-11	2.32E-11	3.87E-11	4.65E-13	1.94E-13	1.94E-11
Picker	1	5.48E-09	5.84E-09	8.77E-09	1.46E-08	1.75E-10	7.30E-11	7.30E-09
Drinking Water	1	3.64E-09	3.64E-09	3.49E-09	5.82E-09	1.46E-09	2.91E-09	2.91E-09
Eating Berries	1	5.00E-09	5.00E-09	4.80E-09	8.00E-09	2.00E-09	4.00E-09	4.00E-09
Eating Vegets.	1	1.00E-08	1.00E-08	9.60E-09	1.60E-08	4.00E-09	8.00E-09	8.00E-09
Eating Deer	1	6.14E-10	6.15E-10	5.98E-10	9.97E-10	2.41E-10	4.80E-10	4.99E-10
Eating Fish	1	1.46E-09	1.46E-09	1.40E-09	2.33E-09	5.82E-10	1.16E-09	1.16E-09
Combined Routes of Exposure								
Hiker	1	4.67E-09	4.74E-09	5.14E-09	8.56E-09	1.49E-09	2.93E-09	4.28E-09
Berry Picker	1	1.51E-08	1.56E-08	1.87E-08	3.11E-08	3.66E-09	7.00E-09	1.56E-08
Hunter	1	6.87E-09	6.94E-09	7.33E-09	1.22E-08	2.33E-09	4.59E-09	6.10E-09
Fisherman	1	6.12E-09	6.19E-09	6.54E-09	1.09E-08	2.07E-09	4.09E-09	5.45E-09
Resident	1	1.47E-08	1.47E-08	1.47E-08	2.46E-08	5.49E-09	1.09E-08	1.23E-08
For 30 Exposures								
Dermal, Spray Vegetation Contact	30	3.04E-08	3.24E-08	4.86E-08	8.10E-08	9.72E-10	4.05E-10	4.05E-08
Hiker	30	4.36E-10	4.65E-10	6.97E-10	1.16E-09	1.39E-11	5.81E-12	5.81E-10
Picker	30	1.64E-07	1.75E-07	2.63E-07	4.38E-07	5.26E-09	2.19E-09	2.19E-07
Drinking Water	30	1.09E-07	1.09E-07	1.05E-07	1.75E-07	4.37E-08	8.74E-08	8.74E-08
Eating Berries	30	1.50E-07	1.50E-07	1.44E-07	2.40E-07	6.00E-08	1.20E-07	1.20E-07
Eating Vegets.	30	3.00E-07	3.00E-07	2.88E-07	4.80E-07	1.20E-07	2.40E-07	2.40E-07
Eating Deer	30	1.84E-08	1.84E-08	1.80E-08	2.99E-08	7.22E-09	1.44E-08	1.50E-08
Eating Fish	30	4.37E-08	4.37E-08	4.19E-08	6.99E-08	1.75E-08	3.49E-08	3.49E-08
Combined Routes of Exposure								
Hiker	30	1.40E-07	1.42E-07	1.54E-07	2.57E-07	4.47E-08	8.78E-08	1.28E-07
Berry Picker	30	4.54E-07	4.67E-07	5.60E-07	9.34E-07	1.10E-07	2.10E-07	4.67E-07
Hunter	30	2.06E-07	2.08E-07	2.20E-07	3.66E-07	6.98E-08	1.38E-07	1.83E-07
Fisherman	30	1.84E-07	1.86E-07	1.96E-07	3.27E-07	6.21E-08	1.23E-07	1.63E-07
Resident	30	4.40E-07	4.42E-07	4.42E-07	7.37E-07	1.65E-07	3.28E-07	3.69E-07

Table B-30
Lifetime Doses for Exposed Public (mg/kg/day) Large Right of Way, Worst Case

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray	1	5.77E-09	7.51E-09	1.17E-08	2.35E-08	2.25E-10	1.88E-10	1.17E-08
Vegetation Contact								
Hiker	1	8.28E-11	1.08E-10	1.68E-10	3.37E-10	3.23E-12	2.69E-12	1.68E-10
Picker	1	1.49E-08	1.94E-08	3.02E-08	6.05E-08	5.81E-10	4.84E-10	3.02E-08
Drinking Water	1	7.99E-09	9.74E-09	9.74E-09	1.95E-08	3.90E-09	1.56E-08	9.74E-09
Eating Berries	1	1.24E-08	1.52E-08	1.52E-08	3.03E-08	6.07E-09	2.43E-08	1.52E-08
Eating Vegets.	1	2.49E-08	3.03E-08	3.03E-08	6.07E-08	1.21E-08	4.85E-08	3.03E-08
Eating Deer	1	1.55E-09	1.89E-09	1.92E-09	3.84E-09	7.39E-10	2.95E-09	1.92E-09
Eating Fish	1	3.20E-09	3.90E-09	3.90E-09	7.79E-09	1.56E-09	6.23E-09	3.90E-09
Combined Routes of Exposure								
Hiker	1	1.38E-08	1.74E-08	2.16E-08	4.33E-08	4.13E-09	1.58E-08	2.16E-08
Berry Picker	1	4.11E-08	5.18E-08	6.69E-08	1.34E-07	1.08E-08	4.05E-08	6.69E-08
Hunter	1	1.96E-08	2.44E-08	2.90E-08	5.79E-08	6.80E-09	2.64E-08	2.90E-08
Fisherman	1	1.70E-08	2.13E-08	2.55E-08	5.11E-08	5.68E-09	2.20E-08	2.55E-08
Resident	1	3.87E-08	4.77E-08	5.20E-08	1.04E-07	1.63E-08	6.43E-08	5.20E-08
For 30 Exposures								
Dermal, Spray	30	1.73E-07	2.25E-07	3.52E-07	7.04E-07	6.76E-09	5.63E-09	3.52E-07
Vegetation Contact								
Hiker	30	2.48E-09	3.23E-09	5.05E-09	1.01E-08	9.70E-11	8.08E-11	5.05E-09
Picker	30	4.46E-07	5.81E-07	9.07E-07	1.81E-06	1.74E-08	1.45E-08	9.07E-07
Drinking Water	30	2.40E-07	2.92E-07	2.92E-07	5.85E-07	1.17E-07	4.68E-07	2.92E-07
Eating Berries	30	3.73E-07	4.55E-07	4.55E-07	9.10E-07	1.82E-07	7.28E-07	4.55E-07
Eating Vegets.	30	7.46E-07	9.10E-07	9.10E-07	1.82E-06	3.64E-07	1.46E-06	9.10E-07
Eating Deer	30	4.65E-08	5.68E-08	5.76E-08	1.15E-07	2.22E-08	8.85E-08	5.76E-08
Eating Fish	30	9.59E-08	1.17E-07	1.17E-07	2.34E-07	4.68E-08	1.87E-07	1.17E-07
Combined Routes of Exposure								
Hiker	30	4.15E-07	5.21E-07	6.49E-07	1.30E-06	1.24E-07	4.73E-07	6.49E-07
Berry Picker	30	1.23E-06	1.55E-06	2.01E-06	4.01E-06	3.23E-07	1.22E-06	2.01E-06
Hunter	30	5.89E-07	7.33E-07	8.69E-07	1.74E-06	2.04E-07	7.93E-07	8.69E-07
Fisherman	30	5.11E-07	6.38E-07	7.66E-07	1.53E-06	1.71E-07	6.60E-07	7.66E-07
Resident	30	1.16E-06	1.43E-06	1.56E-06	3.12E-06	4.88E-07	1.93E-06	1.56E-06

Table B-31
Lifetime Doses for Exposed Public (mg/kg/day) Accidental Spraying

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Dermal, Spray	1	4.02E-06	5.22E-06	8.16E-06	1.63E-05	3.92E-07	1.31E-07	8.16E-06
Vegetation Contact								
Hiker	1	5.76E-08	7.49E-08	1.17E-07	2.34E-07	5.62E-09	1.87E-09	1.17E-07
Picker	1	1.04E-05	1.35E-05	2.10E-05	4.21E-05	1.01E-06	3.37E-07	2.10E-05
Drinking Water	1	2.35E-06	2.87E-06	2.87E-06	5.74E-06	2.87E-06	4.59E-06	2.87E-06
Eating Berries	1	1.87E-06	2.28E-06	2.28E-06	4.56E-06	2.28E-06	3.65E-06	2.28E-06
Eating Vegets.	1	3.88E-06	4.73E-06	4.73E-06	9.47E-06	4.73E-06	7.57E-06	4.73E-06
Eating Deer	1	4.02E-07	4.92E-07	5.11E-07	1.02E-06	4.60E-07	7.34E-07	5.11E-07
Eating Fish	1	9.42E-07	1.15E-06	1.15E-06	2.30E-06	1.15E-06	1.84E-06	1.15E-06
Combined Routes of Exposure								
Hiker	1	6.43E-06	8.17E-06	1.12E-05	2.23E-05	3.27E-06	4.73E-06	1.12E-05
Berry Picker	1	1.86E-05	2.38E-05	3.44E-05	6.87E-05	6.55E-06	8.71E-06	3.44E-05
Hunter	1	9.35E-06	1.18E-05	1.49E-05	2.98E-05	6.58E-06	1.00E-05	1.49E-05
Fisherman	1	7.37E-06	9.32E-06	1.23E-05	2.46E-05	4.42E-06	6.56E-06	1.23E-05
Resident	1	1.03E-05	1.29E-05	1.59E-05	3.18E-05	8.00E-06	1.23E-05	1.59E-05
For 30 Exposures								
Dermal, Spray	30	1.20E-04	1.57E-04	2.45E-04	4.90E-04	1.18E-05	3.92E-06	2.45E-04
Vegetation Contact								
Hiker	30	1.73E-06	2.25E-06	3.51E-06	7.03E-06	1.69E-07	5.62E-08	3.51E-06
Picker	30	3.11E-04	4.04E-04	6.31E-04	1.26E-03	3.03E-05	1.01E-05	6.31E-04
Drinking Water	30	7.06E-05	8.61E-05	8.61E-05	1.72E-04	8.61E-05	1.38E-04	8.61E-05
Eating Berries	30	5.61E-05	6.84E-05	6.84E-05	1.37E-04	6.84E-05	1.09E-04	6.84E-05
Eating Vegets.	30	1.16E-04	1.42E-04	1.42E-04	2.84E-04	1.42E-04	2.27E-04	1.42E-04
Eating Deer	30	1.20E-05	1.48E-05	1.53E-05	3.07E-05	1.38E-05	2.20E-05	1.53E-05
Eating Fish	30	2.83E-05	3.45E-05	3.45E-05	6.89E-05	3.45E-05	5.51E-05	3.45E-05
Combined Routes of Exposure								
Hiker	30	1.93E-04	2.45E-04	3.35E-04	6.69E-04	9.81E-05	1.42E-04	3.35E-04
Berry Picker	30	5.58E-04	7.15E-04	1.03E-03	2.06E-03	1.97E-04	2.61E-04	1.03E-03
Hunter	30	2.81E-04	3.53E-04	4.47E-04	8.94E-04	1.98E-04	3.00E-04	4.47E-04
Fisherman	30	2.21E-04	2.80E-04	3.69E-04	7.38E-04	1.33E-04	1.97E-04	3.69E-04
Resident	30	3.09E-04	3.87E-04	4.77E-04	9.53E-04	2.40E-04	3.69E-04	4.77E-04

Table B-32
Lifetime Doses for Exposure Due to Spills (mg/kg/day)

	Exposures per Lifetime	Average Daily Dose for Exclusive Use of						
		2,4-D	2,4-DP	Asulam	Bromacil	Picloram	Amitrole	Glyphosate
For a Single Exposure								
Spills onto Skin								
Concentrate	1	5.64E-03	9.02E-03	9.39E-03	9.39E-03	2.25E-04	4.70E-05	7.05E-03
Spray Mix	1	5.64E-04	3.76E-04	7.84E-04	4.70E-04	5.64E-05	9.39E-06	1.17E-03
Spills Into Water (1 Liter Drunk)								
Pond, Helo.	1	2.88E-06	1.80E-06	2.41E-06	----	3.60E-06	2.88E-06	3.60E-06
Reserv., Helo.	1	9.01E-08	5.63E-08	7.52E-08	----	1.13E-07	9.01E-08	1.13E-07
Pond, Truck	1	2.88E-05	1.80E-05	2.41E-05	1.44E-05	3.60E-05	2.88E-05	3.60E-05
Reserv., Truck	1	9.01E-07	5.63E-07	7.52E-07	4.50E-07	1.13E-06	9.01E-07	1.13E-06

Attachment C

Margins of Safety for Doses to Workers and the Public Calculated in the Risk Analysis

Margins of Safety for Doses to Workers in Routine Operations

Table C-1
Margins of Safety for Workers Using Amitrole

	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.03)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (5.00)
Routine-Realistic Exposures				
PILOT	0.0004	1000000 +	62	12000
MIXER/LOADER	0.0006	1000000 +	43	8700
SUPERVISOR	0.0001	1000000 +	410	81000
OBSERVER	0.0000	1000000 +	1900	380000
BACKPACK	0.0033	1000000 +	7.6	1500
R-O-W SPRAYER	0.0001	1000000 +	360	73000
R-O-W MIX/L	0.0001	1000000 +	360	72000
R-O-W AP/M/L	0.0001	1000000 +	260	52000
HACK & SQUIRT	0.0006	1000000 +	45	9000
INJECTION BAR	0.0002	1000000 +	120	24000
Routine-Worst Case Exposures				
PILOT	0.0067	610000	3.7	750
MIXER/LOADER	0.0085	480000	2.9	590
SUPERVISOR	0.0012	1000000 +	22	4300
OBSERVER	0.0002	1000000 +	120	24000
BACKPACK	0.0310	130000	-1.2	160
R-O-W SPRAYER	0.0042	960000	5.9	1200
R-O-W MIX/L	0.0024	1000000 +	10	2000
R-O-W AP/M/L	0.0029	1000000 +	8.7	1700
HACK & SQUIRT	0.0063	650000	4.0	790
INJECTION BAR	0.0017	1000000 +	15	3000

[a] The plus sign (+) means "greater than."

Table C-2
Margins of Safety for Workers Using Asulam

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
Routine-Realistic Exposures				
PILOT	0.0483	83000	1000	1000
MIXER/LOADER	0.0693	58000	720	720
SUPERVISOR	0.0074	540000	6800	6800
OBSERVER	0.0016	1000000 +	32000	32000
BACKPACK	0.1978	20000	250	250
R-O-W SPRAYER	0.0082	490000	6100	6100
R-O-W MIX/L	0.0084	480000	6000	6000
R-O-W AP/M/L	0.0116	350000	4300	4300
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.5591	7200	89	89
MIXER/LOADER	0.7128	5600	70	70
SUPERVISOR	0.0969	41000	520	520
OBSERVER	0.0173	230000	2900	2900
BACKPACK	2.0693	1900	24	24
R-O-W SPRAYER	0.2652	15000	190	190
R-O-W MIX/L	0.1530	26000	330	330
R-O-W AP/M/L	0.1787	22000	280	280
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-3
Margins of Safety for Workers Using Atrazine

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
Routine-Realistic Exposures				
PILOT	0.0755	25000	49	1300
MIXER/LOADER	0.1083	17000	34	920
SUPERVISOR	0.0116	160000	320	8700
OBSERVER	0.0025	760000	1500	41000
BACKPACK	0.4946	3800	7.5	200
R-O-W SPRAYER	0.0103	180000	360	9700
R-O-W MIX/L	0.0105	180000	350	9500
R-O-W AP/M/L	0.0145	130000	260	6900
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.6696	2800	5.5	150
MIXER/LOADER	0.8536	2200	4.3	120
SUPERVISOR	0.1160	16000	32	860
OBSERVER	0.0207	90000	180	4800
BACKPACK	2.4782	750	1.5	40
R-O-W SPRAYER	0.4509	4100	8.2	220
R-O-W MIX/L	0.2601	7200	14	380
R-O-W AP/M/L	0.3038	6200	12	330
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

Table C-4
Margins of Safety for Workers Using Bromacil

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
Routine-Realistic Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	0.6595	6100	9.5	12
R-O-W SPRAYER	0.0137	290000	460	580
R-O-W MIX/L	0.0140	290000	450	570
R-O-W AP/M/L	0.0193	210000	320	410
HACK & SQUIRT	0.1113	36000	56	71
INJECTION BAR	0.0424	94000	150	190
Routine-Worst Case Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	6.1955	650	1.0	1.3
R-O-W SPRAYER	0.5305	7500	12	15
R-O-W MIX/L	0.3060	13000	20	26
R-O-W AP/M/L	0.3574	11000	17	22
HACK & SQUIRT	1.2617	3200	5.0	6.3
INJECTION BAR	0.3373	12000	19	23

Table C-5
Margins of Safety for Workers Using 2,4-D

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (25.00)
Routine-Realistic Exposures				
PILOT	0.0302	12000	33	830
MIXER/LOADER	0.0433	8700	23	580
SUPERVISOR	0.0046	81000	220	5400
OBSERVER	0.0010	380000	1000	26000
BACKPACK	0.1978	1900	5.1	130
R-O-W SPRAYER	0.0051	73000	190	4900
R-O-W MIX/L	0.0052	72000	190	4800
R-O-W AP/M/L	0.0072	52000	140	3500
HACK & SQUIRT	0.0998	5600	15	370
INJECTION BAR	0.0254	15000	39	980
Routine-Worst Case Exposures				
PILOT	0.4018	930	2.5	62
MIXER/LOADER	0.5122	730	2.0	49
SUPERVISOR	0.0696	5400	14	360
OBSERVER	0.0124	30000	81	2000
BACKPACK	1.4869	250	-1.5	17
R-O-W SPRAYER	0.1305	2900	7.7	190
R-O-W MIX/L	0.0753	5000	13	330
R-O-W AP/M/L	0.0879	4300	11	280
HACK & SQUIRT	0.7570	500	1.3	33
INJECTION BAR	0.2024	1900	4.9	120

Table C-6
Margins of Safety for Workers Using 2,4-DP

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (6.25)
Routine-Realistic Exposures				
PILOT	0.0258	21000	190	240
MIXER/LOADER	0.0370	14000	140	170
SUPERVISOR	0.0039	130000	1300	1600
OBSERVER	0.0008	640000	6000	7500
BACKPACK	0.2110	2500	24	30
R-O-W SPRAYER	0.0055	97000	910	1100
R-O-W MIX/L	0.0056	95000	890	1100
R-O-W AP/M/L	0.0077	69000	650	810
HACK & SQUIRT	0.1069	5000	47	58
INJECTION BAR	0.0407	13000	120	150
Routine-Worst Case Exposures				
PILOT	0.2678	2000	19	23
MIXER/LOADER	0.3414	1600	15	18
SUPERVISOR	0.0464	11000	110	130
OBSERVER	0.0083	64000	600	760
BACKPACK	1.7060	310	2.9	3.7
R-O-W SPRAYER	0.1698	3100	29	37
R-O-W MIX/L	0.0979	5400	51	64
R-O-W AP/M/L	0.1144	4700	44	55
HACK & SQUIRT	1.2112	440	4.1	5.2
INJECTION BAR	0.3238	1600	15	19

Table C-7
Margins of Safety for Workers Using Dalapon

	EXPOSURE (MG/KG/DAY)	LD_{50} (7577.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (15.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (300.00)
Routine-Realistic Exposures				
PILOT	0.0806	94000	190	3700
MIXER/LOADER	0.1156	66000	130	2600
SUPERVISOR	0.0123	620000	1200	24000
OBSERVER	0.0026	1000000 +	5700	110000
BACKPACK	0.6595	11000	23	450
R-O-W SPRAYER	0.0137	550000	1100	22000
R-O-W MIX/L	0.0140	540000	1100	21000
R-O-W AP/M/L	0.0193	390000	780	16000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	1.6740	4500	9.0	18 0
MIXER/LOADER	2.1340	3600	7.0	14 0
SUPERVISOR	0.2900	26000	52	1000
OBSERVER	0.0517	150000	290	5800
BACKPACK	7.4346	1000	2.0	40
R-O-W SPRAYER	0.5305	14000	28	570
R-O-W MIX/L	0.3060	25000	49	980
R-O-W AP/M/L	0.3574	21000	42	840
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a]The plus sign (+) means "greater than."

Table C-8
Margins of Safety for Workers Using Dicamba

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (2.50)
Routine-Realistic Exposures				
PILOT	0.0101	75000	2500	250
MIXER/LOADER	0.0144	52000	1700	170
SUPERVISOR	0.0015	490000	16000	1600
OBSERVER	0.0003	1000000 +	77000	7700
BACKPACK	0.0412	18000	610	61
R-O-W SPRAYER	0.0017	440000	15000	1500
R-O-W MIX/L	0.0017	430000	14000	1400
R-O-W AP/M/L	0.0024	310000	10000	1000
HACK & SQUIRT	0.0557	14000	450	45
INJECTION BAR	0.0212	36000	1200	120
Routine-Worst Case Exposures				
PILOT	0.3348	2300	75	7.5
MIXER/LOADER	0.4268	1800	59	5.9
SUPERVISOR	0.0580	13000	430	43
OBSERVER	0.0103	73000	2400	240
BACKPACK	1.2391	610	20	2.0
R-O-W SPRAYER	0.0955	7900	260	26
R-O-W MIX/L	0.0551	14000	450	45
R-O-W AP/M/L	0.0643	12000	390	39
HACK & SQUIRT	0.6308	1200	40	4.0
INJECTION BAR	0.1686	4500	150	15

[a]The plus sign (+) means "greater than."

Table C-9
Margins of Safety for Workers Using Diuron

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
Routine-Realistic Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	0.6595	5700	-1.1	9.5
R-O-W SPRAYER	0.0137	270000	46	460
R-O-W MIX/L	0.0140	270000	45	450
R-O-W AP/M/L	0.0193	190000	32	320
HACK & SQUIRT	0.1113	34000	5.6	56
INJECTION BAR	0.0424	89000	15	150
Routine-Worst Case Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	3.7173	1000	-5.9	1.7
R-O-W SPRAYER	0.8488	4400	-1.4	7.4
R-O-W MIX/L	0.4896	7700	1.3	13
R-O-W AP/M/L	0.5719	6600	1.1	11
HACK & SQUIRT	1.2617	3000	-2.0	5.0
INJECTION BAR	0.3373	11000	1.9	19

Table C-10
Margins of Safety for Workers Using Fosamine

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
Routine-Realistic Exposures				
PILOT	0.0604	400000	410	12000
MIXER/LOADER	0.0867	280000	290	8700
SUPERVISOR	0.0092	1000000 +	2700	81000
OBSERVER	0.0020	1000000 +	13000	380000
BACKPACK	0.4946	49000	51	1500
R-O-W SPRAYER	0.0137	1000000 +	1800	55000
R-O-W MIX/L	0.0140	1000000 +	1800	54000
R-O-W AP/M/L	0.0193	1000000 +	1300	39000
HACK & SQUIRT	0.1113	220000	220	6700
INJECTION BAR	0.0424	580000	590	18000
Routine-Worst Case Exposures				
PILOT	2.0088	12000	12	370
MIXER/LOADER	2.5608	9500	9.8	290
SUPERVISOR	0.3480	70000	72	2200
OBSERVER	0.0620	390000	400	12000
BACKPACK	7.1248	3400	3.5	110
R-O-W SPRAYER	0.5678	43000	44	1300
R-O-W MIX/L	0.3274	75000	76	2300
R-O-W AP/M/L	0.3824	64000	65	2000
HACK & SQUIRT	1.2617	19000	20	590
INJECTION BAR	0.3373	72000	74	2200

[a] The plus sign (+) means "greater than."

Table C-11
Margins of Safety for Workers Using Glyphosate

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
Routine-Realistic Exposures				
PILOT	0.0403	110000	740	250
MIXER/LOADER	0.0578	75000	520	170
SUPERVISOR	0.0062	700000	4900	1600
OBSERVER	0.0013	1000000 +	23000	7700
BACKPACK	0.2473	17000	120	40
R-O-W SPRAYER	0.0069	630000	4400	1500
R-O-W MIX/L	0.0070	620000	4300	1400
R-O-W AP/M/L	0.0096	450000	3100	1000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.8370	5200	36	12
MIXER/LOADER	1.0670	4000	28	9.4
SUPERVISOR	0.1450	30000	210	69
OBSERVER	0.0258	170000	1200	390
BACKPACK	3.0978	1400	9.7	3.2
R-O-W SPRAYER	0.2652	16000	110	38
R-O-W MIX/L	0.1530	28000	200	66
R-O-W AP/M/L	0.1787	24000	170	56
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a]The plus sign (+) means "greater than."

Table C-12
Margins of Safety for Workers Using Hexazinone

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
Routine-Realistic Exposures				
PILOT	0.0504	34000	200	2500
MIXER/LOADER	0.0722	23000	140	1700
SUPERVISOR	0.0077	220000	1300	16000
OBSERVER	0.0016	1000000	6100	77000
BACKPACK	0.1846	9200	54	680
R-O-W SPRAYER	0.0086	200000	1200	15000
R-O-W MIX/L	0.0087	190000	1100	14000
R-O-W AP/M/L	0.0120	140000	830	10000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.5022	3400	20	250
MIXER/LOADER	0.6402	2600	16	200
SUPERVISOR	0.0870	19000	110	1400
OBSERVER	0.0155	110000	650	8100
BACKPACK	1.8587	910	5.4	67
R-O-W SPRAYER	0.3183	5300	31	390
R-O-W MIX/L	0.1836	9200	54	680
R-O-W AP/M/L	0.2145	7900	47	580
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

Table C-13
Margins of Safety for Workers Using Picloram

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (50.00)
Routine-Realistic Exposures				
PILOT	0.0010	1000000 +	7200	52000
MIXER/LOADER	0.0014	1000000 +	5000	36000
SUPERVISOR	0.0001	1000000 +	47000	340000
OBSERVER	0.0000	1000000 +	220000	1000000 +
BACKPACK	0.0079	1000000	880	6300
R-O-W SPRAYER	0.0002	1000000 +	43000	300000
R-O-W MIX/L	0.0002	1000000 +	42000	300000
R-O-W AP/M/L	0.0002	1000000 +	30000	220000
HACK & SQUIRT	0.0027	1000000 +	2600	19000
INJECTION BAR	0.0010	1000000 +	6900	49000
Routine-Worst Case Exposures				
PILOT	0.0402	200000	170	1200
MIXER/LOADER	0.0512	160000	140	980
SUPERVISOR	0.0070	1000000 +	1000	7200
OBSERVER	0.0012	1000000 +	5600	40000
BACKPACK	0.1190	69000	59	420
R-O-W SPRAYER	0.0051	1000000 +	1400	9800
R-O-W MIX/L	0.0029	1000000 +	2400	17000
R-O-W AP/M/L	0.0034	1000000 +	2000	15000
HACK & SQUIRT	0.0303	270000	230	1700
INJECTION BAR	0.0081	1000000	860	6200

[a] The plus sign (+) means "greater than."

Table C-14
Margins of Safety for Workers Using Simazine

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (5.00)
Routine-Realistic Exposures				
PILOT	0.0806	62000	62	62
MIXER/LOADER	0.1156	43000	43	43
SUPERVISOR	0.0123	410000	410	410
OBSERVER	0.0026	1000000 +	1900	1900
BACKPACK	0.3297	15000	15	15
R-O-W SPRAYER	0.0069	730000	730	730
R-O-W MIX/L	0.0070	720000	720	720
R-O-W AP/M/L	0.0096	520000	520	520
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.8370	6000	6.0	6.0
MIXER/LOADER	1.0670	4700	4.7	4.7
SUPERVISOR	0.1450	34000	34	34
OBSERVER	0.0268	190000	190	190
BACKPACK	2.8499	1800	1.8	1.8
R-O-W SPRAYER	0.2440	20000	20	20
R-O-W MIX/L	0.1408	36000	36	36
R-O-W AP/M/L	0.1644	30000	30	30
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-15
Margins of Safety for Workers Using Tebuthiuron

	EXPOSURE (MG/KG/DAY)	LD_{50} (644.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (12.50)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (90.00)
Routine-Realistic Exposures				
PILOT	0.0201	32000	620	4500
MIXER/LOADER	0.0289	22000	430	3100
SUPERVISOR	0.0031	210000	4100	29000
OBSERVER	0.0007	990000	19000	140000
BACKPACK	0.2473	2600	51	360
R-O-W SPRAYER	0.0075	85000	1700	12000
R-O-W MIX/L	0.0077	84000	1600	12000
R-O-W AP/M/L	0.0106	61000	1200	8500
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	1.0044	640	12	90
MIXER/LOADER	1.2804	500	9.8	70
SUPERVISOR	0.1740	3700	72	520
OBSERVER	0.0310	21000	400	2900
BACKPACK	3.7173	170	3.4	24
R-O-W SPRAYER	0.2440	2600	51	370
R-O-W MIX/L	0.1408	4600	89	640
R-O-W AP/M/L	0.1644	3900	76	550
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

Table C-16
Margins of Safety for Workers Using Triclopyr

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (2.50)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (10.00)
Routine-Realistic Exposures				
PILOT	0.0403	16000	62	250
MIXER/LOADER	0.0578	11000	43	170
SUPERVISOR	0.0062	100000	410	1600
OBSERVER	0.0013	480000	1900	7700
BACKPACK	0.3297	1900	7.6	30
R-O-W SPRAYER	0.0069	92000	360	1500
R-O-W MIX/L	0.0070	90000	360	1400
R-O-W AP/M/L	0.0096	65000	260	1000
HACK & SQUIRT	0.1113	5700	22	90
INJECTION BAR	0.0424	15000	59	240
Routine-Worst Case Exposures				
PILOT	1.3392	470	1.9	7.5
MIXER/LOADER	1.7072	370	1.5	5.9
SUPERVISOR	0.2320	2700	11	43
OBSERVER	0.0413	15000	60	240
BACKPACK	4.9564	130	-2.0	2.0
R-O-W SPRAYER	0.4244	1500	5.9	24
R-O-W MIX/L	0.2448	2600	10	41
R-O-W AP/M/L	0.2859	2200	8.7	35
HACK & SQUIRT	1.2617	500	2.0	7.9
INJECTION BAR	0.3373	1900	7.4	30

Margins of Safety for Doses to Workers Wearing Protective Clothing in Routine Operations

Table C-17
Margins of Safety for Workers Wearing Protective Clothing and Using Amitrole

	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.03)	REPRODUCTIVE NOEL (5.00)
Routine-Realistic Exposures				
PILOT	0.0002	1000000+	150	30000
MIXER/LOADER	0.0004	1000000+	59	12000
SUPERVISOR	0.0000	1000000+	970	190000
OBSERVER	0.0000	1000000+	4600	910000
BACKPACK	0.0010	1000000+	24	4900
R-O-W SPRAYER	0.0000	1000000+	1200	230000
R-O-W MIX/L	0.0001	1000000+	490	98000
R-O-W AP/M/L	0.0001	1000000+	500	100000
HACK & SQUIRT	0.0002	1000000+	110	21000
INJECTION BAR	0.0001	1000000+	260	52000
Routine-Worst Case Exposures				
PILOT	0.0028	1000000+	8.9	1800
MIXER/LOADER	0.0062	660000	4.0	800
SUPERVISOR	0.0005	1000000+	51	10000
OBSERVER	0.0001	1000000+	290	58000
BACKPACK	0.0097	420000	2.6	520
R-O-W SPRAYER	0.0013	1000000+	19	3800
R-O-W MIX/L	0.0018	1000000+	14	2800
R-O-W AP/M/L	0.0015	1000000+	17	3400
HACK & SQUIRT	0.0027	1000000+	9.3	1900
INJECTION BAR	0.0008	1000000+	33	6600

[a]The plus sign (+) means "greater than."

Table C-18
Margins of Safety for Workers Wearing Protective Clothing and Using Asulam

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	REPRODUCTIVE NOEL (50.00)
Routine-Realistic Exposures				
PILOT	0.0203	200000	3000	2500
MIXER/LOADER	0.0505	79000	1200	990
SUPERVISOR	0.0031	1000000+	19000	16000
OBSERVER	0.0007	1000000+	91000	76000
BACKPACK	0.0617	65000	970	810
R-O-W SPRAYER	0.0026	1000000+	23000	19000
R-O-W MIX/L	0.0061	650000	9800	8200
R-O-W AP/M/L	0.0060	860000	10000	8300
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.2343	17000	260	210
MIXER/LOADER	0.5196	7700	120	96
SUPERVISOR	0.0406	99000	1500	1200
OBSERVER	0.0072	550000	8300	6900
BACKPACK	0.6456	6200	93	77
R-O-W SPRAYER	0.0828	48000	730	600
R-O-W MIX/L	0.1115	36000	540	450
R-O-W AP/M/L	0.0930	43000	650	540
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a]The plus sign (+) means "greater than."

Table C-19
Margins of Safety for Workers Wearing Protective Clothing and Using Atrazine

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	REPRODUCTIVE NOEL (100.00)
Routine-Realistic Exposures				
PILOT	0.0317	59000	120	3200
MIXER/LOADER	0.0790	24000	47	1300
SUPERVISOR	0.0048	390000	760	21000
OBSERVER	0.0010	1000000+	3600	97000
BACKPACK	0.1543	12000	24	650
R-O-W SPRAYER	0.0032	580000	1200	31000
R-O-W MIX/L	0.0076	240000	480	13000
R-O-W AP/M/L	0.0075	250000	490	13000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.2806	6700	13	360
MIXER/LOADER	0.6223	3000	5.9	160
SUPERVISOR	0.0486	38000	76	2100
OBSERVER	0.0087	220000	430	12000
BACKPACK	0.7732	2400	4.8	130
R-O-W SPRAYER	0.1407	13000	26	710
R-O-W MIX/L	0.1896	9900	20	530
R-O-W AP/M/L	0.1581	12000	23	630
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-20
Margins of Safety for Workers Wearing Protective Clothing and Using Bromacil

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	REPRODUCTIVE NOEL (7.92)
Routine-Realistic Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	0.2057	19000	30	38
R-O-W SPRAYER	0.0043	930000	1500	1900
R-O-W MIX/L	0.0102	390000	610	780
R-O-W AP/M/L	0.0100	400000	620	790
HACK & SQUIRT	0.0472	85000	130	170
INJECTION BAR	0.0192	210000	330	410
Routine-Worst Case Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	1.9330	2100	3.2	4.1
R-O-W SPRAYER	0.1655	24000	38	48
R-O-W MIX/L	0.2231	18000	28	36
R-O-W AP/M/L	0.1860	21000	34	43
HACK & SQUIRT	0.5350	7500	12	15
INJECTION BAR	0.1528	26000	41	52

Table C-21
Margins of Safety for Workers Wearing Protective Clothing and Using 2,4-D

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (25.00)
Routine-Realistic Exposures				
PILOT	0.0127	30000	79	2000
MIXER/LOADER	0.0316	12000	32	790
SUPERVISOR	0.0019	190000	520	13000
OBSERVER	0.0004	910000	2400	61000
BACKPACK	0.0617	6100	16	410
R-O-W SPRAYER	0.0016	230000	620	16000
R-O-W MIX/L	0.0038	98000	260	6500
R-O-W AP/M/L	0.0038	100000	270	6600
HACK & SQUIRT	0.0283	13000	35	880
INJECTION BAR	0.0115	33000	87	2200
Routine-Worst Case Exposures				
PILOT	0.1683	2200	5.9	150
MIXER/LOADER	0.3734	1000	2.7	67
SUPERVISOR	0.0292	13000	34	860
OBSERVER	0.0052	72000	190	4800
BACKPACK	0.4639	810	2.2	54
R-O-W SPRAYER	0.0407	9200	25	610
R-O-W MIX/L	0.0549	6800	18	460
R-O-W AP/M/L	0.0468	8000	22	550
HACK & SQUIRT	0.3210	1200	3.1	78
INJECTION BAR	0.0917	4100	11	270

Table C-22
Margins of Safety for Workers Wearing Protective Clothing and Using 2,4-DP

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (6.25)
Routine-Realistic Exposures				
PILOT	0.0106	49000	460	580
MIXER/LOADER	0.0270	20000	190	230
SUPERVISOR	0.0017	320000	3000	3800
OBSERVER	0.0004	1000000 +	14000	18000
BACKPACK	0.0658	8100	76	95
R-O-W SPRAYER	0.0017	310000	2900	3700
R-O-W MIX/L	0.0041	130000	1200	1500
R-O-W AP/M/L	0.0040	130000	1200	1600
HACK & SQUIRT	0.0453	12000	110	140
INJECTION BAR	0.0184	29000	270	340
Routine-Worst Case Exposures				
PILOT	0.1122	4700	45	56
MIXER/LOADER	0.2489	2100	20	25
SUPERVISOR	0.0194	27000	260	320
OBSERVER	0.0035	150000	1400	1800
BACKPACK	0.5320	1000	9.4	12
R-O-W SPRAYER	0.0530	10000	94	120
R-O-W MIX/L	0.0714	7500	70	88
R-O-W AP/M/L	0.0595	8900	84	100
HACK & SQUIRT	0.5136	1000	9.7	12
INJECTION BAR	0.1467	3600	34	43

[a] The plus sign (+) means "greater than."

Table C-23
Margins of Safety for Workers Wearing Protective Clothing and Using Dalapon

	EXPOSURE (MG/KG/DAY)	LD_{50} (7577.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (15.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (300.00)
Routine-Realistic Exposures				
PILOT	0.0038	220000	440	8900
MIXER/LOADER	0.0842	90000	180	3600
SUPERVISOR	0.0052	1000000 +	2900	58000
OBSERVER	0.0011	1000000 +	14000	270000
BACKPACK	0.2057	37000	73	1500
R-O-W SPRAYER	0.0043	1000000 +	3500	70000
R-O-W MIX/L	0.0102	740000	1500	29000
R-O-W AP/M/L	0.0100	760000	1500	30000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.7014	11000	21	430
MIXER/LOADER	1.5557	4900	9.6	190
SUPERVISOR	0.1215	62000	120	2500
OBSERVER	0.0216	350000	690	14000
BACKPACK	2.3196	3300	6.5	130
R-O-W SPRAYER	0.1655	46000	91	1800
R-O-W MIX/L	0.2231	34000	67	1300
R-O-W AP/M/L	0.1860	41000	81	1600
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-24
Margins of Safety for Workers Wearing Protective Clothing and Using Dicamba

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (2.50)
Routine-Realistic Exposures				
PILOT	0.0042	180000	5900	590
MIXER/LOADER	0.0105	72000	2400	240
SUPERVISOR	0.0006	1000000 +	39000	3900
OBSERVER	0.0001	1000000 +	180000	18000
BACKPACK	0.0129	59000	1900	190
R-O-W SPRAYER	0.0005	1000000 +	47000	4700
R-O-W MIX/L	0.0013	590000	20000	2000
R-O-W AP/M/L	0.0013	600000	20000	2000
HACK & SQUIRT	0.0236	32000	1100	110
INJECTION BAR	0.0096	79000	2600	260
Routine-Worst Case Exposures				
PILOT	0.1403	5400	180	18
MIXER/LOADER	0.3111	2400	80	8.0
SUPERVISOR	0.0243	31000	1000	100
OBSERVER	0.0043	170000	5800	580
BACKPACK	0.3866	2000	65	6.5
R-O-W SPRAYER	0.0298	25000	840	84
R-O-W MIX/L	0.0402	19000	620	62
R-O-W AP/M/L	0.0335	23000	750	75
HACK & SQUIRT	0.2675	2800	93	9.3
INJECTION BAR	0.0764	9900	330	33

[a] The plus sign (+) means "greater than."

Table C-25
Margins of Safety for Workers Wearing Protective Clothing and Using Diuron

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
Routine-Realistic Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	0.2057	18000	3.0	30
R-O-W SPRAYER	0.0043	880000	150	1500
R-O-W MIX/L	0.0102	370000	61	610
R-O-W AP/M/L	0.0100	370000	62	620
HACK & SQUIRT	0.0472	79000	13	130
INJECTION BAR	0.0192	200000	33	330
Routine-Worst Case Exposures				
PILOT	---	---	---	---
MIXER/LOADER	---	---	---	---
SUPERVISOR	---	---	---	---
OBSERVER	---	---	---	---
BACKPACK	1.1598	3200	-1.9	5.4
R-O-W SPRAYER	0.2648	14000	2.4	24
R-O-W MIX/L	0.3569	11000	1.8	18
R-O-W AP/M/L	0.2977	13000	2.1	21
HACK & SQUIRT	0.5350	7000	1.2	12
INJECTION BAR	0.1528	25000	4.1	41

Table C-26
Margins of Safety for Workers Wearing Protective Clothing and Using Fosamine

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
Routine-Realistic Exposures				
PILOT	0.0253	980000	990	30000
MIXER/LOADER	0.0632	390000	400	12000
SUPERVISOR	0.0039	1000000 +	6500	190000
OBSERVER	0.0008	1000000 +	30000	910000
BACKPACK	0.1543	160000	160	4900
R-O-W SPRAYER	0.0043	1000000 +	5800	180000
R-O-W MIX/L	0.0102	1000000 +	2500	74000
R-O-W AP/M/L	0.0100	1000000 +	2500	75000
HACK & SQUIRT	0.0472	520000	530	16000
INJECTION BAR	0.0192	1000000 +	1300	39000
Routine-Worst Case Exposures				
PILOT	0.8417	29000	30	890
MIXER/LOADER	1.8668	13000	13	400
SUPERVISOR	0.1458	170000	170	5100
OBSERVER	0.0260	940000	960	29000
BACKPACK	2.2229	11000	11	340
R-O-W SPRAYER	0.1771	140000	140	4200
R-O-W MIX/L	0.2367	100000	100	3100
R-O-W AP/M/L	0.1981	120000	130	3800
HACK & SQUIRT	0.5350	46000	47	1400
INJECTION BAR	0.1528	160000	160	4900

[a]The plus sign (+) means "greater than."

Table C-27
Margins of Safety for Workers Wearing Protective Clothing and Using Glyphosate

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
Routine-Realistic Exposures				
PILOT	0.0169	260000	1800	590
MIXER/LOADER	0.0421	100000	710	240
SUPERVISOR	0.0026	1000000 +	12000	3900
OBSERVER	0.0005	1000000 +	55000	18000
BACKPACK	0.0772	56000	390	130
R-O-W SPRAYER	0.0021	1000000 +	14000	4700
R-O-W MIX/L	0.0051	850000	5900	2000
R-O-W AP/M/L	0.0050	860000	6000	2000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.3507	12000	86	29
MIXER/LOADER	0.7778	5600	39	13
SUPERVISOR	0.0608	71000	490	160
OBSERVER	0.0108	400000	2800	920
BACKPACK	0.9665	4500	31	10
R-O-W SPRAYER	0.0828	52000	360	120
R-O-W MIX/L	0.1115	39000	270	90
R-O-W AP/M/L	0.0930	46000	320	110
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-28
Margins of Safety for Workers Wearing Protective Clothing and Using Hexazinone

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
Routine-Realistic Exposures				
PILOT	0.0211	80000	470	5900
MIXER/LOADER	0.0526	32000	190	2400
SUPERVISOR	0.0032	520000	3100	39000
OBSERVER	0.0007	1000000 +	15000	180000
BACKPACK	0.0576	29000	170	2200
R-O-W SPRAYER	0.0027	630000	3700	47000
R-O-W MIX/L	0.0064	270000	1600	20000
R-O-W AP/M/L	0.0063	270000	1600	20000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.2104	8000	48	590
MIXER/LOADER	0.4667	3600	21	270
SUPERVISOR	0.0365	46000	270	3400
OBSERVER	0.0065	260000	1500	19000
BACKPACK	0.5799	2900	17	220
R-O-W SPRAYER	0.0993	17000	100	1300
R-O-W MIX/L	0.1338	13000	75	930
R-O-W AP/M/L	0.1116	15000	90	1100
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-29
Margins of Safety for Workers Wearing Protective Clothing and Using Picloram

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (50.0)
Routine-Realistic Exposures				
PILOT	0.0004	1000000 +	17000	120000
MIXER/LOADER	0.0010	1000000 +	6900	49000
SUPERVISOR	0.0001	1000000 +	110000	810000
OBSERVER	0.0000	1000000 +	530000	1000000 +
BACKPACK	0.0025	1000000 +	2800	20000
R-O-W SPRAYER	0.0001	1000000 +	140000	970000
R-O-W MIX/L	0.0001	1000000 +	57000	410000
R-O-W AP/M/L	0.0001	1000000 +	58000	420000
HACK & SQUIRT	0.0011	1000000 +	6200	44000
INJECTION BAR	0.0005	1000000 +	15000	110000
Routine-Worst Case Exposures				
PILOT	0.0168	490000	420	3000
MIXER/LOADER	0.0373	220000	190	1300
SUPERVISOR	0.0029	1000000 +	2400	17000
OBSERVER	0.0005	1000000 +	13000	96000
BACKPACK	0.0371	220000	190	1300
R-O-W SPRAYER	0.0016	1000000 +	4400	31000
R-O-W MIX/L	0.0021	1000000 +	3300	23000
R-O-W AP/M/L	0.0018	1000000 +	3900	28000
HACK & SQUIRT	0.0128	640000	550	3900
INJECTION BAR	0.0037	1000000 +	1900	14000

[a] The plus sign (+) means "greater than."

Table C-30
Margins of Safety for Workers Wearing Protective Clothing and Using Simazine

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (5.00)
Routine-Realistic Exposures				
PILOT	0.0338	150000	150	150
MIXER/LOADER	0.0842	59000	59	59
SUPERVISOR	0.0052	970000	970	970
OBSERVER	0.0011	1000000 +	4600	4600
BACKPACK	0.1029	49000	49	49
R-O-W SPRAYER	0.0021	1000000 +	2300	2300
R-O-W MIX/L	0.0051	980000	980	980
R-O-W AP/M/L	0.0050	1000000	1000	1000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.3507	14000	14	14
MIXER/LOADER	0.7778	6400	6.4	6.4
SUPERVISOR	0.0608	82000	82	82
OBSERVER	0.0108	460000	460	460
BACKPACK	0.8892	5600	5.6	5.6
R-O-W SPRAYER	0.0761	66000	66	66
R-O-W MIX/L	0.1026	49000	49	49
R-O-W AP/M/L	0.0856	58000	58	58
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-31
Margins of Safety for Workers Wearing Protective Clothing and Using Tebuthiuron

	EXPOSURE (MG/KG/DAY)	LD_{50} (644.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (12.50)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (90.00)
Routine-Realistic Exposures				
PILOT	0.0084	76000	1500	11000
MIXER/LOADER	0.0211	31000	590	4300
SUPERVISOR	0.0013	500000	9700	70000
OBSERVER	0.0003	1000000 +	46000	330000
BACKPACK	0.0772	8300	160	1200
R-O-W SPRAYER	0.0024	270000	5300	38000
R-O-W MIX/L	0.0056	110000	2200	16000
R-O-W AP/M/L	0.0055	120000	2300	16000
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---
Routine-Worst Case Exposures				
PILOT	0.4208	1500	30	210
MIXER/LOADER	0.9334	690	13	96
SUPERVISOR	0.0729	8800	170	1200
OBSERVER	0.0130	50000	960	6900
BACKPACK	1.1598	560	11	78
R-O-W SPRAYER	0.0761	8500	160	1200
R-O-W MIX/L	0.1026	6300	120	880
R-O-W AP/M/L	0.0856	7500	150	1100
HACK & SQUIRT	---	---	---	---
INJECTION BAR	---	---	---	---

[a] The plus sign (+) means "greater than."

Table C-32
Margins of Safety for Workers Wearing Protective Clothing and Using Triclopyr

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (2.50)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (10.00)
Routine-Realistic Exposures				
PILOT	0.0169	37000	150	590
MIXER/LOADER	0.0421	15000	59	240
SUPERVISOR	0.0026	240000	970	3900
OBSERVER	0.0005	1000000 +	4600	18000
BACKPACK	0.1029	6100	24	97
R-O-W SPRAYER	0.0021	290000	1200	4700
R-O-W MIX/L	0.0051	120000	490	2000
R-O-W AP/M/L	0.0050	130000	500	2000
HACK & SQUIRT	0.0472	13000	53	210
INJECTION BAR	0.0192	33000	130	520
Routine-Worst Case Exposures				
PILOT	0.5611	1100	4.5	18
MIXER/LOADER	1.2445	510	2.0	8.0
SUPERVISOR	0.0972	6500	26	100
OBSERVER	0.0173	36000	140	580
BACKPACK	1.5464	410	1.6	6.5
R-O-W SPRAYER	0.1324	4800	19	76
R-O-W MIX/L	0.1784	3500	14	56
R-O-W AP/M/L	0.1488	4200	17	67
HACK & SQUIRT	0.5350	1200	4.7	19
INJECTION BAR	0.1528	4100	16	65

[a] The plus sign (+) means "greater than."

Table C-33
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Amitrol Sprayed on 40 acres by Helicopter

			MARGIN OF SAFETY RELATIVE TO	
	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	SYSTEMIC NOEL (0.03)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000+	160000	1000000+
VEGETATION CONTACT				
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0000	1000000+	770	150000
DRINKING WATER	0.0019	1000000+	13	2700
EATING BERRIES	0.0011	1000000+	23	4600
EATING VEGETS.	0.0022	1000000+	12	2300
EATING DEER	0.0001	1000000+	170	34000
EATING BIRD	0.0005	1000000+	51	10000
EATING FISH	0.0008	1000000+	33	6600
For Combined Routes of Exposure				
HIKER	0.0019	1000000+	13	2700
BERRY PICKER	0.0030	1000000+	8.3	1700
HUNTER	0.0025	1000000+	9.9	2000
FISHERMAN	0.0026	1000000+	9.5	1900
RESIDENT	0.0040	1000000	6.2	1200

[a] The plus sign (+) means "greater than."

Table C-34
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Amitrole Sprayed on 6 acres

			MARGIN OF SAFETY RELATIVE TO	
	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	SYSTEMIC NOEL (0.03)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000+	14000	1000000+
VEGETATION CONTACT				
HIKER	0.0000	1000000+	980000	1000000+
PICKER	0.0000	1000000+	3500	710000
DRINKING WATER	0.0002	1000000+	150	30000
EATING BERRIES	0.0003	1000000+	82	16000
EATING VEGETS.	0.0006	1000000+	41	8200
EATING DEER	0.0000	1000000+	660	130000
EATING BIRD	0.0001	1000000+	230	46000
EATING FISH	0.0001	1000000+	380	75000
For Combined Routes of Exposure:				
HIKER	0.0002	1000000+	150	30000
BERRY PICKER	0.0005	1000000+	52	10000
HUNTER	0.0003	1000000+	79	16000
FISHERMAN	0.0002	1000000+	110	21000
RESIDENT	0.0008	1000000+	32	6400

[a]The plus sign (+) means "greater than."

Table C-35
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Amitrole Sprayed on 12 acres

			MARGIN OF SAFETY RELATIVE TO	
	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	SYSTEMIC NOEL (0.03)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000+	72000	1000000+
VEGETATION CONTACT				
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0000	1000000+	13000	1000000+
DRINKING WATER	0.0001	1000000+	340	67000
EATING BERRIES	0.0001	1000000+	240	49000
EATING VEGETS.	0.0002	1000000+	120	24000
EATING DEER	0.0000	1000000+	2000	410000
EATING BIRD	0.0000	1000000+	820	160000
EATING FISH	0.0000	1000000+	840	170000
For Combined Routes of Exposure				
HIKER	0.0001	1000000+	330	67000
BERRY PICKER	0.0002	1000000+	140	28000
HUNTER	0.0001	1000000+	210	43000
FISHERMAN	0.0001	1000000+	240	48000
RESIDENT	0.0003	1000000+	90	18000

[a]The plus sign (+) means "greater than."

Table C-36
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Amitrole Sprayed on 400 acres by Fixed Wing

			MARGIN OF SAFETY RELATIVE TO	
	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	SYSTEMIC NOEL (0.03)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0002	1000000+	150	29000
VEGETATION CONTACT				
HIKER	0.0000	1000000+	10000	1000000+
PICKER	0.0004	1000000+	57	11000
DRINKING WATER	0.0127	320000	2.0	390
EATING BERRIES	0.0104	390000	2.4	480
EATING VEGETS.	0.0208	200000	1.2	240
EATING DEER	0.0015	1000000+	16	3300
EATING BIRD	0.0063	650000	4.0	800
EATING FISH	0.0051	800000	4.9	990
For Combined Routes of Exposure				
HIKER	0.0129	320000	1.9	390
BERRY PICKER	0.0237	170000	1.1	210
HUNTER	0.0206	200000	1.2	240
FISHERMAN	0.0179	230000	1.4	280
RESIDENT	0.0337	120000	-1.3	150

[a]The plus sign (+) means "greater than."

Table C-37
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Amitrole Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (0.03)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	2900	580000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	200000	1000000 +
PICKER	0.0000	1000000 +	1100	230000
DRINKING WATER	0.0005	1000000 +	52	10000
EATING BERRIES	0.0009	1000000 +	27	5400
EATING VEGETS.	0.0018	1000000 +	14	2700
EATING DEER	0.0001	1000000 +	220	43000
EATING BIRD	0.0003	1000000 +	74	15000
EATING FISH	0.0002	1000000 +	130	26000
For Combined Routes of Exposure				
HIKER	0.0005	1000000 +	51	10000
BERRY PICKER	0.0014	1000000 +	17	3500
HUNTER	0.0009	1000000 +	27	5300
FISHERMAN	0.0007	1000000 +	37	7400
RESIDENT	0.0023	1000000 +	11	2100

[a]The plus sign (+) means "greater than."

Table C-38
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Worst Case Scenario Amitrole Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (0.03)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	5200	1000000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	360000	1000000 +
PICKER	0.0000	1000000 +	2000	400000
DRINKING WATER	0.0004	1000000 +	63	13000
EATING BERRIES	0.0006	1000000 +	40	8100
EATING VEGETS.	0.0012	1000000 +	20	4000
EATING DEER	0.0001	1000000 +	330	66000
EATING BIRD	0.0002	1000000 +	130	25000
EATING FISH	0.0002	1000000 +	160	31000
For Combined Routes of Exposure				
HIKER	0.0004	1000000 +	62	12000
BERRY PICKER	0.0010	1000000 +	24	4800
HUNTER	0.0007	1000000 +	37	7400
FISHERMAN	0.0006	1000000 +	44	8900
RESIDENT	0.0016	1000000 +	15	3000

[a]The plus sign (+) means "greater than."

Table C-39
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Asulam Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (50.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	1000000 +	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0039	1000000	13000	13000
DRINKING WATER	0.0023	1000000 +	22000	22000
EATING BERRIES	0.0013	1000000 +	39000	39000
EATING VEGETS.	0.0026	1000000 +	19000	19000
EATING DEER	0.0002	1000000 +	270000	270000
EATING BIRD	0.0007	1000000 +	76000	76000
EATING FISH	0.0009	1000000 +	55000	55000
For Combined Routes of Exposure				
HIKER	0.0023	1000000 +	22000	22000
BERRY PICKER	0.0075	540000	6700	6700
HUNTER	0.0031	1000000 +	16000	16000
FISHERMAN	0.0032	1000000 +	16000	16000
RESIDENT	0.0049	820000	10000	10000

[a]The plus sign (+) means "greater than."

Table C-40
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Asulam Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (50.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	470000	470000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0004	1000000 +	120000	120000
DRINKING WATER	0.0001	1000000 +	500000	500000
EATING BERRIES	0.0002	1000000 +	270000	270000
EATING VEGETS.	0.0004	1000000 +	140000	140000
EATING DEER	0.0000	1000000 +	1000000 +	1000000 +
EATING BIRD	0.0001	1000000 +	680000	680000
EATING FISH	0.0000	1000000 +	1000000 +	1000000 +
For Combined Routes of Exposure				
HIKER	0.0002	1000000 +	240000	240000
BERRY PICKER	0.0008	1000000 +	62000	62000
HUNTER	0.0003	1000000 +	160000	160000
FISHERMAN	0.0002	1000000 +	200000	200000
RESIDENT	0.0006	1000000 +	87000	87000

[a]The plus sign (+) means "greater than."

Table C-41
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Asulam Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	1000000 +	1000000 +
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0002	1000000 +	220000	220000
DRINKING WATER	0.0001	1000000 +	560000	560000
EATING BERRIES	0.0001	1000000 +	410000	410000
EATING VEGETS.	0.0002	1000000 +	200000	200000
EATING DEER	0.0000	1000000 +	1000000 +	1000000 +
EATING BIRD	0.0000	1000000 +	1000000 +	1000000 +
EATING FISH	0.0000	1000000 +	1000000 +	1000000 +
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	380000	380000
BERRY PICKER	0.0005	1000000 +	100000	100000
HUNTER	0.0002	1000000 +	270000	270000
FISHERMAN	0.0002	1000000 +	300000	300000
RESIDENT	0.0004	1000000 +	130000	130000

[a]The plus sign (+) means "greater than."

Table C-42
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Asulam Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0142	280000	3500	3500
HIKER	0.0002	1000000 +	250000	250000
PICKER	0.0366	110000	1400	1400
DRINKING WATER	0.0106	380000	4700	4700
EATING BERRIES	0.0087	460000	5700	5700
EATING VEGETS.	0.0174	230000	2900	2900
EATING DEER	0.0014	1000000 +	37000	37000
EATING BIRD	0.0059	670000	8400	8400
EATING FISH	0.0042	940000	12000	12000
For Combined Routes of Exposure				
HIKER	0.0250	160000	2000	2000
BERRY PICKER	0.0700	57000	710	710
HUNTER	0.0323	120000	1500	1500
FISHERMAN	0.0292	140000	1700	1700
RESIDENT	0.0424	94000	1200	1200

[a]The plus sign (+) means "greater than."

Table C-43
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Asulam Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0006	1000000 +	87000	87000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0015	1000000 +	34000	34000
DRINKING WATER	0.0003	1000000 +	160000	160000
EATING BERRIES	0.0006	1000000 +	81000	81000
EATING VEGETS.	0.0012	1000000 +	41000	41000
EATING DEER	0.0001	1000000 +	620000	620000
EATING BIRD	0.0003	1000000 +	200000	200000
EATING FISH	0.0001	1000000 +	390000	390000
For Combined Routes of Exposure				
HIKER	0.0009	1000000 +	56000	56000
BERRY PICKER	0.0030	1000000 +	17000	17000
HUNTER	0.0012	1000000 +	40000	40000
FISHERMAN	0.0010	1000000 +	49000	49000
RESIDENT	0.0021	1000000 +	23000	23000

[a] The plus sign (+) means "greater than."

Table C-44
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Asulam Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0003	1000000 +	170000	170000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0008	1000000 +	66000	66000
DRINKING WATER	0.0002	1000000 +	200000	200000
EATING BERRIES	0.0004	1000000 +	130000	130000
EATING VEGETS.	0.0008	1000000 +	64000	64000
EATING DEER	0.0000	1000000 +	1000000 +	1000000 +
EATING BIRD	0.0001	1000000 +	360000	360000
EATING FISH	0.0001	1000000 +	500000	500000
For Combined Routes of Exposure				
HIKER	0.0006	1000000 +	90000	90000
BERRY PICKER	0.0017	1000000 +	29000	29000
HUNTER	0.0007	1000000 +	68000	68000
FISHERMAN	0.0007	1000000 +	77000	77000
RESIDENT	0.0013	1000000 +	38000	38000

[a] The plus sign (+) means "greater than."

Table C-45
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Atrazine Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	120000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0061	310000	610	16000
DRINKING WATER	0.0035	530000	1000	28000
EATING BERRIES	0.0020	920000	1800	49000
EATING VEGETS.	0.0040	460000	910	25000
EATING DEER	0.0003	1000000 +	13000	350000
EATING BIRD	0.0010	1000000 +	3600	97000
EATING FISH	0.0071	260000	520	14000
For Combined Routes of Exposure				
HIKER	0.0036	520000	1000	28000
BERRY PICKER	0.0117	160000	320	8600
HUNTER	0.0049	380000	760	20000
FISHERMAN	0.0106	180000	350	9400
RESIDENT	0.0076	250000	490	13000

[a] The plus sign (+) means "greater than."

Table C-46
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Atrazine Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0003	1000000 +	14000	370000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	970000	1000000 +
PICKER	0.0011	1000000 +	3500	95000
DRINKING WATER	0.0002	1000000 +	15000	400000
EATING BERRIES	0.0005	1000000 +	8100	220000
EATING VEGETS.	0.0009	1000000 +	4000	110000
EATING DEER	0.0001	1000000 +	62000	1000000 +
EATING BIRD	0.0002	1000000 +	20000	540000
EATING FISH	0.0005	1000000 +	7400	200000
For Combined Routes of Exposure				
HIKER	0.0005	1000000 +	7100	190000
BERRY PICKER	0.0020	920000	1800	49000
HUNTER	0.0008	1000000 +	4800	130000
FISHERMAN	0.0010	1000000 +	3600	98000
RESIDENT	0.0014	1000000 +	2600	70000

[a] The plus sign (+) means "greater than."

Table C-47
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Atrazine Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	72000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0003	1000000 +	13000	360000
DRINKING WATER	0.0001	1000000 +	33000	900000
EATING BERRIES	0.0002	1000000 +	24000	650000
EATING VEGETS.	0.0003	1000000 +	12000	330000
EATING DEER	0.0000	1000000 +	190000	1000000 +
EATING BIRD	0.0001	1000000 +	73000	1000000 +
EATING FISH	0.0002	1000000 +	17000	450000
For Combined Routes of Exposure				
HIKER	0.0002	1000000 +	23000	610000
BERRY PICKER	0.0006	1000000 +	6200	170000
HUNTER	0.0002	1000000 +	16000	430000
FISHERMAN	0.0004	1000000 +	9600	260000
RESIDENT	0.0005	1000000 +	7900	210000

[a] The plus sign (+) means "greater than."

Table C-48
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Atrazine Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0170	110000	220	5900
VEGETATION CONTACT				
HIKER	0.0002	1000000 +	15000	410000
PICKER	0.0438	43000	85	2300
DRINKING WATER	0.0127	150000	290	7900
EATING BERRIES	0.0104	180000	350	9600
EATING VEGETS.	0.0208	90000	180	4800
EATING DEER	0.0016	1000000 +	2300	61000
EATING BIRD	0.0071	260000	520	14000
EATING FISH	0.0254	74000	150	3900
For Combined Routes of Exposure				
HIKER	0.0299	62000	120	3300
BERRY PICKER	0.0839	22000	44	1200
HUNTER	0.0386	48000	96	2600
FISHERMAN	0.0553	34000	67	1800
RESIDENT	0.0508	37000	73	2000

[a] The plus sign (+) means "greater than."

Table C-49
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Atrazine Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (3.70)	REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0007	1000000 +	5400	150000
HIKER	0.0000	1000000 +	380000	1000000 +
PICKER	0.0018	1000000 +	2100	57000
DRINKING WATER	0.0004	1000000 +	9700	260000
EATING BERRIES	0.0007	1000000 +	5000	140000
EATING VEGETS.	0.0015	1000000 +	2500	68000
EATING DEER	0.0001	1000000 +	38000	1000000
EATING BIRD	0.0003	1000000 +	12000	330000
EATING FISH	0.0008	1000000 +	4800	130000
For Combined Routes of Exposure				
HIKER	0.0011	1000000 +	3400	93000
BERRY PICKER	0.0036	520000	1000	28000
HUNTER	0.0015	1000000 +	2500	68000
FISHERMAN	0.0018	1000000	2000	54000
RESIDENT	0.0026	730000	1400	39000

[a] The plus sign (+) means "greater than."

Table C-50
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Atrazine Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (3.70)	REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0005	1000000 +	7300	200000
HIKER	0.0000	1000000 +	510000	1000000 +
PICKER	0.0013	1000000 +	2800	76000
DRINKING WATER	0.0004	1000000 +	9700	260000
EATING BERRIES	0.0007	1000000 +	5600	150000
EATING VEGETS.	0.0013	1000000 +	2800	76000
EATING DEER	0.0001	1000000 +	44000	1000000 +
EATING BIRD	0.0002	1000000 +	16000	430000
EATING FISH	0.0008	1000000 +	4400	120000
For Combined Routes of Exposure				
HIKER	0.0009	1000000 +	3900	110000
BERRY PICKER	0.0029	640000	1300	34000
HUNTER	0.0013	1000000 +	2900	80000
FISHERMAN	0.0018	1000000	2100	56000
RESIDENT	0.0023	830000	1600	44000

[a] The plus sign (+) means "greater than."

Table C-51
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Bromacil [1/] Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (6.25)	REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	---	---	---	---
HIKER	---	---	---	---
PICKER	---	---	---	---
DRINKING WATER	---	---	---	---
EATING BERRIES	---	---	---	---
EATING VEGETS.	---	---	---	---
EATING DEER	---	---	---	---
EATING BIRD	---	---	---	---
EATING FISH	---	---	---	---
For Combined Routes of Exposure				
HIKER	---	---	---	---
BERRY PICKER	---	---	---	---
HUNTER	---	---	---	---
FISHERMAN	---	---	---	---
RESIDENT	---	---	---	---

[1/] Scenario is inapplicable

Table C-52
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Bromacil Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (6.25)	REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0004	1000000 +	18000	22000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0014	1000000 +	4400	5600
DRINKING WATER	0.0003	1000000 +	19000	24000
EATING BERRIES	0.0006	1000000 +	10000	13000
EATING VEGETS.	0.0012	1000000 +	5100	6500
EATING DEER	0.0001	1000000 +	78000	99000
EATING BIRD	0.0002	1000000 +	26000	32000
EATING FISH	0.0001	1000000 +	47000	60000
For Combined Routes of Exposure:				
HIKER	0.0007	1000000 +	9000	11000
BERRY PICKER	0.0027	1000000 +	2300	2900
HUNTER	0.0010	1000000 +	6100	7800
FISHERMAN	0.0008	1000000 +	7600	9600
RESIDENT	0.0019	1000000 +	3300	4100

[a] The plus sign (+) means "greater than."

Table C-53
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Bromacil Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL SPRAY	0.0001	1000000+	91000	110000
VEGETATION CONTACT				
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0004	1000000+	17000	21000
DRINKING WATER	0.0001	1000000+	42000	53000
EATING BERRIES	0.0002	1000000+	31000	39000
EATING VEGETS.	0.0004	1000000+	15000	19000
EATING DEER	0.0000	1000000+	250000	310000
EATING BIRD	0.0001	1000000+	92000	120000
EATING FISH	0.0001	1000000+	100000	130000
For Combined Routes of Exposure				
HIKER	0.0002	1000000+	29000	36000
BERRY PICKER	0.0008	1000000+	7900	10000
HUNTER	0.0003	1000000+	20000	25000
FISHERMAN	0.0003	1000000+	22000	28000
RESIDENT	0.0006	1000000+	10000	13000

[a] The plus sign (+) means "greater than."

Table C-54
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Bromacil[1/] Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.9)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL SPRAY	---	---	---	---
VEGETATION CONTACT				
HIKER	---	---	---	---
PICKER	---	---	---	---
DRINKING WATER	---	---	---	---
EATING BERRIES	---	---	---	---
EATING VEGETS.	---	---	---	---
EATING DEER	---	---	---	---
EATING BIRD	---	---	---	---
EATING FISH	---	---	---	---
For Combined Routes of Exposure				
HIKER	---	---	---	---
BERRY PICKER	---	---	---	---
HUNTER	---	---	---	---
FISHERMAN	---	---	---	---
RESIDENT	---	---	---	---

[1/] Scenario is inapplicable

Table C-55
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Bromacil Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL SPRAY	0.0017	1000000+	3600	4600
VEGETATION CONTACT				
HIKER	0.0000	1000000+	250000	320000
PICKER	0.0044	910000	1400	1800
DRINKING WATER	0.0010	1000000+	6500	8300
EATING BERRIES	0.0018	1000000+	3400	4300
EATING VEGETS.	0.0037	1000000+	1700	2100
EATING DEER	0.0002	1000000+	26000	33000
EATING BIRD	0.0008	1000000+	8200	10000
EATING FISH	0.0004	1000000+	16000	21000
For Combined Routes of Exposure				
HIKER	0.0027	1000000+	2300	2900
BERRY PICKER	0.0089	450000	700	890
HUNTER	0.0037	1000000+	1700	2100
FISHERMAN	0.0031	1000000+	2000	2600
RESIDENT	0.0064	630000	980	1200

[a] The plus sign (+) means "greater than."

Table C-56
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Bromacil Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL SPRAY	0.0006	1000000+	10000	13000
VEGETATION CONTACT				
HIKER	0.0000	1000000+	730000	920000
PICKER	0.0015	1000000+	4000	5100
DRINKING WATER	0.0005	1000000+	13000	16000
EATING BERRIES	0.0008	1000000+	8100	10000
EATING VEGETS.	0.0016	1000000+	4000	5100
EATING DEER	0.0001	1000000+	64000	81000
EATING BIRD	0.0003	1000000+	23000	29000
EATING FISH	0.0002	1000000+	31000	40000
For Combined Routes of Exposure				
HIKER	0.0011	1000000+	5700	7200
BERRY PICKER	0.0034	1000000+	1800	2300
HUNTER	0.0015	1000000+	4200	5400
FISHERMAN	0.0013	1000000+	4800	6100
RESIDENT	0.0027	1000000+	2400	3000

[a] The plus sign (+) means "greater than."

Table C-57
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario 2,4-D Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	83000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0024	150000	410	10000
DRINKING WATER	0.0024	160000	420	11000
EATING BERRIES	0.0013	280000	740	19000
EATING VEGETS.	0.0027	140000	370	9300
EATING DEER	0.0002	1000000 +	5300	130000
EATING BIRD	0.0007	570000	1500	38000
EATING FISH	0.0009	400000	1100	27000
For Combined Routes of Exposure:				
HIKER	0.0024	160000	420	11000
BERRY PICKER	0.0061	61000	160	4100
HUNTER	0.0032	120000	310	7800
FISHERMAN	0.0033	110000	300	7600
RESIDENT	0.0051	74000	200	4900

[a] The plus sign (+) means "greater than."

Table C-58
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario 2,4-D Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	9400	230000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	850000	1000000 +
PICKER	0.0004	890000	2400	59000
DRINKING WATER	0.0002	1000000 +	6000	150000
EATING BERRIES	0.0003	1000000 +	3300	82000
EATING VEGETS.	0.0006	610000	1600	41000
EATING DEER	0.0000	1000000 +	26000	640000
EATING BIRD	0.0001	1000000 +	8500	210000
EATING FISH	0.0001	1000000 +	15000	380000
For Combined Routes of Exposure:				
HIKER	0.0003	1000000 +	3600	91000
BERRY PICKER	0.0010	370000	1000	25000
HUNTER	0.0004	870000	2300	58000
FISHERMAN	0.0003	1000000 +	2900	73000
RESIDENT	0.0009	420000	1100	28000

[a] The plus sign (+) means "greater than."

Table C-59
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario 2,4-D Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	39000	970000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0001	1000000 +	7100	180000
DRINKING WATER	0.0001	1000000 +	11000	270000
EATING BERRIES	0.0001	1000000 +	7800	200000
EATING VEGETS.	0.0003	1000000 +	3900	96000
EATING DEER	0.0000	1000000 +	64000	1000000 +
EATING BIRD	0.0000	1000000 +	25000	620000
EATING FISH	0.0000	1000000 +	27000	670000
For Combined Routes of Exposure:				
HIKER	0.0001	1000000 +	8400	210000
BERRY PICKER	0.0004	970000	2600	65000
HUNTER	0.0002	1000000 +	5700	140000
FISHERMAN	0.0002	1000000 +	6400	160000
RESIDENT	0.0004	1000000	2700	67000

[a] The plus sign (+) means "greater than."

Table C-60
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario 2,4-D Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0102	37000	98	2500
VEGETATION CONTACT				
HIKER	0.0001	1000000 +	6800	170000
PICKER	0.0263	14000	38	950
DRINKING WATER	0.0127	30000	79	2000
EATING BERRIES	0.0104	36000	96	2400
EATING VEGETS.	0.0208	18000	48	1200
EATING DEER	0.0016	240000	630	16000
EATING BIRD	0.0088	55000	150	3700
EATING FISH	0.0051	74000	200	4900
For Combined Routes of Exposure				
HIKER	0.0230	16000	43	1100
BERRY PICKER	0.0596	6300	17	420
HUNTER	0.0314	12000	32	800
FISHERMAN	0.0281	13000	36	890
RESIDENT	0.0439	8500	23	570

[a] The plus sign (+) means "greater than."

Table C-61
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario 2,4-D Sprayed on 60 acres

For Single Route of Exposure	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
DERMAL, SPRAY	0.0004	910000	2400	61000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	170000	1000000 +
PICKER	0.0011	350000	940	24000
DRINKING WATER	0.0004	980000	2600	65000
EATING BERRIES	0.0007	510000	1400	34000
EATING VEGETS.	0.0015	250000	680	17000
EATING DEER	0.0001	1000000 +	11000	260000
EATING BIRD	0.0003	1000000 +	3400	86000
EATING FISH	0.0002	1000000 +	6500	160000
For Combined Routes of Exposure				
HIKER	0.0008	470000	1300	31000
BERRY PICKER	0.0026	140000	390	9700
HUNTER	0.0012	320000	840	21000
FISHERMAN	0.0010	380000	1100	26000
RESIDENT	0.0023	160000	440	11000

[a] The plus sign (+) means "greater than."

Table C-62
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario 2,4-D Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	6800	170000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	470000	1000000 +
PICKER	0.0004	990000	2600	66000
DRINKING WATER	0.0002	1000000 +	4900	120000
EATING BERRIES	0.0003	1000000 +	3100	79000
EATING VEGETS.	0.0006	590000	1600	39000
EATING DEER	0.0000	1000000 +	25000	630000
EATING BIRD	0.0001	1000000 +	9300	230000
EATING FISH	0.0001	1000000 +	12000	310000
For Combined Routes of Exposure:				
HIKER	0.0004	1000000 +	2800	71000
BERRY PICKER	0.0010	360000	950	24000
HUNTER	0.0005	750000	2000	50000
FISHERMAN	0.0004	860000	2300	57000
RESIDENT	0.0010	380000	1000	25000

[a] The plus sign (+) means "greater than."

Table C-63
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario 2,4-DP Sprayed on 40 acres by Helicopter

For Single Route of Exposure	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
DERMAL, SPRAY	0.0000	1000000 +	490000	610000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0021	260000	2400	3000
DRINKING WATER	0.0019	280000	2700	3300
EATING BERRIES	0.0011	490000	4600	5800
EATING VEGETS.	0.0022	250000	2300	2900
EATING DEER	0.0002	1000000 +	33000	41000
EATING BIRD	0.0005	1000000	9500	12000
EATING FISH	0.0008	710000	6800	8300
For Combined Routes of Exposure				
HIKER	0.0019	280000	2600	3300
BERRY PICKER	0.0050	110000	990	1200
HUNTER	0.0026	210000	1900	2400
FISHERMAN	0.0026	200000	1900	2400
RESIDENT	0.0041	130000	1200	1500

[a] The plus sign (+) means "greater than."

Table C-64
Margins of Safety for Exposed Members of the Public Backpack Routine-Realistic Scenario 2,4-DP Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	44000	55000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0005	1000000 +	11000	14000
DRINKING WATER	0.0002	1000000 +	30000	38000
EATING BERRIES	0.0003	1000000 +	16000	20000
EATING VEGETS.	0.0006	870000	8200	10000
EATING DEER	0.0000	1000000 +	130000	160000
EATING BIRD	0.0001	1000000 +	43000	53000
EATING FISH	0.0001	1000000 +	75000	94000
For Combined Routes of Exposure				
HIKER	0.0003	1000000 +	18000	22000
BERRY PICKER	0.0010	510000	4800	6000
HUNTER	0.0004	1000000 +	11000	14000
FISHERMAN	0.0003	1000000 +	14000	18000
RESIDENT	0.0009	600000	5600	7000

[a] The plus sign (+) means "greater than."

Table C-65
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario 2,4-DP Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	180000	230000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0001	1000000 +	33000	42000
DRINKING WATER	0.0001	1000000 +	54000	67000
EATING BERRIES	0.0001	1000000 +	39000	49000
EATING VEGETS.	0.0003	1000000 +	20000	24000
EATING DEER	0.0000	1000000 +	320000	400000
EATING BIRD	0.0000	1000000 +	120000	150000
EATING FISH	0.0000	1000000 +	130000	170000
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	41000	52000
BERRY PICKER	0.0004	1000000 +	13000	16000
HUNTER	0.0002	1000000 +	26000	35000
FISHERMAN	0.0002	1000000 +	32000	40000
RESIDENT	0.0004	1000000 +	13000	17000

[a]The plus sign (+) means "greater than."

Table C-66
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario 2,4-DP Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0068	78000	740	920
VEGETATION CONTACT				
HIKER	0.0001	1000000 +	51000	64000
PICKER	0.0175	30000	290	360
DRINKING WATER	0.0079	67000	630	790
EATING BERRIES	0.0065	82000	770	960
EATING VEGETS.	0.0130	41000	380	480
EATING DEER	0.0010	530000	5000	6300
EATING BIRD	0.0043	130000	1200	1500
EATING FISH	0.0032	170000	1600	2000
For Combined Routes of Exposure				
HIKER	0.0148	36000	340	420
BERRY PICKER	0.0087	14000	130	160
HUNTER	0.0201	27000	250	310
FISHERMAN	0.0180	30000	280	350
RESIDENT	0.0278	19000	180	220

[a] The plus sign (+) means "greater than."

Table C-67
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario 2,4-DP Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0005	1000000 +	11000	13000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	740000	920000
PICKER	0.0012	440000	4100	5100
DRINKING WATER	0.0004	1000000 +	12000	15000
EATING BERRIES	0.0008	670000	6300	7900
EATING VEGETS.	0.0016	340000	3200	3900
EATING DEER	0.0001	1000000 +	49000	61000
EATING BIRD	0.0003	1000000 +	16000	20000
EATING FISH	0.0002	1000000 +	30000	38000
For Combined Routes of Exposure				
HIKER	0.0009	600000	5600	7000
BERRY PICKER	0.0029	180000	1700	2200
HUNTER	0.0013	410000	3800	4800
FISHERMAN	0.0011	510000	4700	5900
RESIDENT	0.0025	220000	2000	2500

[a] The plus sign (+) means "greater than."

Table C-68
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario 2,4-DP Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0002	1000000 +	26000	33000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0005	1000000 +	10000	13000
DRINKING WATER	0.0002	1000000 +	20000	25000
EATING BERRIES	0.0004	1000000 +	13000	16000
EATING VEGETS.	0.0008	690000	6400	8100
EATING DEER	0.0000	1000000 +	100000	130000
EATING BIRD	0.0001	1000000 +	38000	47000
EATING FISH	0.0001	1000000 +	50000	63000
For Combined Routes of Exposure:				
HIKER	0.0004	1000000 +	11000	14000
BERRY PICKER	0.0013	400000	3800	4700
HUNTER	0.0006	850000	8000	10000
FISHERMAN	0.0005	980000	9200	12000
RESIDENT	0.0012	440000	4100	5100

[a] The plus sign (+) means "greater than."

Table C-69
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Dalapon Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (7577.0)	SYSTEMIC NOEL (15.00)	REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	470000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0065	1000000 +	2300	46000
DRINKING WATER	0.0038	1000000 +	4000	80000
EATING BERRIES	0.0022	1000000 +	7000	140000
EATING VEGETS.	0.0043	1000000 +	3500	70000
EATING DEER	0.0003	1000000 +	49000	970000
EATING BIRD	0.0011	1000000 +	14000	270000
EATING FISH	0.0015	1000000 +	10000	200000
For Combined Routes of Exposure				
HIKER	0.0038	1000000 +	3900	79000
BERRY PICKER	0.0124	610000	1200	24000
HUNTER	0.0052	1000000 +	2900	58000
FISHERMAN	0.0053	1000000 +	2800	57000
RESIDENT	0.0081	930000	1800	37000

[a] The plus sign (+) means "greater than."

Table C-70
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Dalapon Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (7577.0)	SYSTEMIC NOEL (15.00)	REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0004	1000000 +	42000	840000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0014	1000000 +	11000	210000
DRINKING WATER	0.0003	1000000 +	45000	900000
EATING BERRIES	0.0006	1000000 +	25000	490000
EATING VEGETS.	0.0012	1000000 +	12000	250000
EATING DEER	0.0001	1000000 +	190000	1000000 +
EATING BIRD	0.0002	1000000 +	61000	1000000 +
EATING FISH	0.0001	1000000 +	110000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0007	1000000 +	22000	430000
BERRY PICKER	0.0027	1000000 +	5500	110000
HUNTER	0.0010	1000000 +	15000	290000
FISHERMAN	0.0008	1000000 +	18000	360000
RESIDENT	0.0019	1000000 +	7800	160000

[a] The plus sign (+) means "greater than."

Table C-71
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Dalapon Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (7577.0)	SYSTEMIC NOEL (15.00)	REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	220000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0004	1000000 +	40000	800000
DRINKING WATER	0.0001	1000000 +	100000	1000000 +
EATING BERRIES	0.0002	1000000 +	73000	1000000 +
EATING VEGETS.	0.0004	1000000 +	37000	730000
EATING DEER	0.0000	1000000 +	590000	1000000 +
EATING BIRD	0.0001	1000000 +	220000	1000000 +
EATING FISH	0.0001	1000000 +	250000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0002	1000000 +	69000	1000000 +
BERRY PICKER	0.0008	1000000 +	19000	380000
HUNTER	0.0003	1000000 +	48000	960000
FISHERMAN	0.0003	1000000 +	54000	1000000 +
RESIDENT	0.0006	1000000 +	24000	480000

[a] The plus sign (+) means "greater than."

Table C-72
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Dalapon Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (7577.0)	SYSTEMIC NOEL (15.00)	REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0425	180000	350	7100
VEGETATION CONTACT				
HIKER	0.0006	1000000 +	25000	490000
PICKER	0.1094	69000	140	2700
DRINKING WATER	0.0317	240000	470	9500
EATING BERRIES	0.0261	290000	580	12000
EATING VEGETS.	0.0521	150000	290	5800
EATING DEER	0.0041	1000000 +	3700	74000
EATING BIRD	0.0178	430000	840	17000
EATING FISH	0.0127	600000	1200	24000
For Combined Routes of Exposure				
HIKER	0.0748	100000	200	4000
BERRY PICKER	0.2097	36000	72	1400
HUNTER	0.0966	78000	160	3100
FISHERMAN	0.0874	87000	170	3400
RESIDENT	0.1269	60000	120	2400

[a] The plus sign (+) means "greater than."

Table C-73
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Dalapon Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (7577.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (15.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0021	1000000 +	7300	150000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	510000	1000000 +
PICKER	0.0053	1000000 +	2800	57000
DRINKING WATER	0.0011	1000000 +	13000	260000
EATING BERRIES	0.0022	1000000 +	6800	140000
EATING VEGETS.	0.0044	1000000 +	3400	68000
EATING DEER	0.0003	1000000 +	52000	1000000
EATING BIRD	0.0009	1000000 +	16000	330000
EATING FISH	0.0005	1000000 +	33000	650000
For Combined Routes of Exposure				
HIKER	0.0032	1000000 +	4600	93000
BERRY PICKER	0.0107	710000	1400	28000
HUNTER	0.0044	1000000 +	3400	68000
FISHERMAN	0.0037	1000000 +	4100	81000
RESIDENT	0.0077	990000	2000	39000

[a]The plus sign (+) means "greater than."

Table C-74
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Dalapon Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (7577.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (15.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0006	1000000 +	25000	500000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0015	1000000 +	9700	190000
DRINKING WATER	0.0005	1000000 +	30000	600000
EATING BERRIES	0.0008	1000000 +	19000	390000
EATING VEGETS.	0.0016	1000000 +	9700	190000
EATING DEER	0.0001	1000000 +	150000	1000000 +
EATING BIRD	0.0003	1000000 +	54000	1000000 +
EATING FISH	0.0002	1000000 +	75000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0011	1000000 +	14000	270000
BERRY PICKER	0.0034	1000000 +	4400	88000
HUNTER	0.0015	1000000 +	10000	200000
FISHERMAN	0.0013	1000000 +	11000	230000
RESIDENT	0.0027	1000000 +	5600	110000

[a]The plus sign (+) means "greater than."

Table C-75
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Dicamba Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	1000000 +	620000
VEGETATION				
CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0008	930000	31000	3100
DRINKING WATER	0.0009	800000	27000	2700
EATING BERRIES	0.0005	1000000 +	46000	4600
EATING VEGETS.	0.0011	700000	23000	2300
EATING DEER	0.0001	1000000 +	330000	33000
EATING BIRD	0.0003	1000000 +	96000	9600
EATING FISH	0.0004	1000000 +	66000	6600
For Combined Routes of Exposure				
HIKER	0.0009	800000	26000	2600
BERRY PICKER	0.0023	330000	11000	1100
HUNTER	0.0013	590000	20000	2000
FISHERMAN	0.0013	570000	19000	1900
RESIDENT	0.0020	370000	12000	1200

[a]The plus sign (+) means "greater than."

Table C-76
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Dicamba Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	1000000 +	110000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0001	1000000 +	280000	28000
DRINKING WATER	0.0000	1000000 +	600000	60000
EATING BERRIES	0.0001	1000000 +	330000	33000
EATING VEGETS.	0.0002	1000000 +	160000	16000
EATING DEER	0.0000	1000000 +	1000000 +	260000
EATING BIRD	0.0000	1000000 +	660000	66000
EATING FISH	0.0000	1000000 +	1000000 +	150000
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	390000	39000
BERRY PICKER	0.0002	1000000 +	110000	11000
HUNTER	0.0001	1000000 +	240000	24000
FISHERMAN	0.0001	1000000 +	310000	31000
RESIDENT	0.0002	1000000 +	120000	12000

[a]The plus sign (+) means "greater than."

Table C-77
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Dicamba Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	1000000 +	290000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0000	1000000 +	540000	54000
DRINKING WATER	0.0000	1000000 +	670000	67000
EATING BERRIES	0.0001	1000000 +	490000	49000
EATING VEGETS.	0.0001	1000000 +	240000	24000
EATING DEER	0.0000	1000000 +	1000000 +	400000
EATING BIRD	0.0000	1000000 +	1000000 +	160000
EATING FISH	0.0000	1000000 +	1000000 +	170000
For Combined Routes of Exposure				
HIKER	0.0000	1000000 +	540000	54000
BERRY PICKER	0.0001	1000000 +	170000	17000
HUNTER	0.0001	1000000 +	370000	37000
FISHERMAN	0.0001	1000000 +	410000	41000
RESIDENT	0.0001	1000000 +	170000	17000

[a]The plus sign (+) means "greater than."

Table C-78
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Dicamba Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0085	89000	2900	290
VEGETATION CONTACT				
HIKER	0.0001	1000000 +	210000	21000
PICKER	0.0219	35000	1100	110
DRINKING WATER	0.0127	60000	2000	200
EATING BERRIES	0.0104	73000	2400	240
EATING VEGETS.	0.0208	36000	60	120
EATING DEER	0.0016	480000	16000	1600
EATING BIRD	0.0067	110000	3700	370
EATING FISH	0.0051	150000	4900	490
For Combined Routes of Exposure				
HIKER	0.0213	36000	1200	120
BERRY PICKER	0.0535	14000	470	47
HUNTER	0.0296	26000	850	85
FISHERMAN	0.0264	29000	950	95
RESIDENT	0.0421	18000	590	59

[a]The plus sign (+) means "greater than."

Table C-79
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Dicamba Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0003	1000000 +	73000	7300
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	510000
PICKER	0.0009	860000	28000	2800
DRINKING WATER	0.0004	1000000 +	65000	6500
EATING BERRIES	0.0007	1000000	34000	3400
EATING VEGETS.	0.0015	510000	17000	1700
EATING DEER	0.0001	1000000 +	260000	26000
EATING BIRD	0.0003	1000000 +	87000	8700
EATING FISH	0.0002	1000000 +	160000	16000
For Combined Routes of Exposure				
HIKER	0.0007	1000000	34000	3400
BERRY PICKER	0.0023	320000	11000	1100
HUNTER	0.0011	680000	22000	2200
FISHERMAN	0.0009	860000	28000	2800
RESIDENT	0.0022	340000	11000	1100

[a]The plus sign (+) means "greater than."

Table C-80
Margins of Safety for Exposed Members of the Public For The Right of Way Routine-Worst Case Scenario Dicamba Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	230000	23000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0003	1000000 +	90000	9000
DRINKING WATER	0.0002	1000000 +	140000	14000
EATING BERRIES	0.0003	1000000 +	90000	9000
EATING VEGETS.	0.0006	1000000 +	45000	4500
EATING DEER	0.0000	1000000 +	720000	72000
EATING BIRD	0.0001	1000000 +	270000	27000
EATING FISH	0.0001	1000000 +	350000	35000
For Combined Routes of Exposure				
HIKER	0.0003	1000000 +	87000	8700
BERRY PICKER	0.0008	900000	30000	3000
HUNTER	0.0004	1000000 +	60000	6000
FISHERMAN	0.0004	1000000 +	69000	6900
RESIDENT	0.0008	890000	30000	3000

[a]The plus sign (+) means "greater than."

Table C-81
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Diuron[1] Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	---	---	---	---
VEGETATION CONTACT				
HIKER	---	---	---	---
PICKER	---	---	---	---
DRINKING WATER	---	---	---	---
EATING BERRIES	---	---	---	---
EATING VEGETS.	---	---	---	---
EATING DEER	---	---	---	---
EATING BIRD	---	---	---	---
EATING FISH	---	---	---	---
For Combined Routes of Exposure				
HIKER	---	---	---	---
BERRY PICKER	---	---	---	---
HUNTER	---	---	---	---
FISHERMAN	---	---	---	---
RESIDENT	---	---	---	---

[1]Scenario is inapplicable

Table C-82
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Diuron Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0004	1000000 +	1800	18000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	120000	1000000 +
PICKER	0.0014	1000000 +	440	4400
DRINKING WATER	0.0003	1000000 +	1900	19000
EATING BERRIES	0.0006	1000000 +	1000	10000
EATING VEGETS.	0.0012	1000000 +	510	5100
EATING DEER	0.0001	1000000 +	7800	78000
EATING BIRD	0.0002	1000000 +	2600	26000
EATING FISH	0.0027	1000000 +	240	2400
For Combined Routes of Exposure				
HIKER	0.0007	1000000 +	900	9000
BERRY PICKER	0.0027	1000000 +	230	2300
HUNTER	0.0010	1000000 +	610	6100
FISHERMAN	0.0033	1000000 +	190	1900
RESIDENT	0.0019	1000000 +	330	3300

[a]The plus sign (+) means "greater than."

Table C-83
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Diuron Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	9100	91000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	630000	1000000 +
PICKER	0.0004	1000000 +	1700	17000
DRINKING WATER	0.0001	1000000 +	4200	42000
EATING BERRIES	0.0002	1000000 +	3100	31000
EATING VEGETS.	0.0004	1000000 +	1500	15000
EATING DEER	0.0000	1000000 +	25000	250000
EATING BIRD	0.0001	1000000 +	9200	92000
EATING FISH	0.0012	1000000 +	520	5200
For Combined Routes of Exposure				
HIKER	0.0002	1000000 +	2900	29000
BERRY PICKER	0.0008	1000000 +	790	7900
HUNTER	0.0003	1000000 +	2000	20000
FISHERMAN	0.0014	1000000 +	440	4400
RESIDENT	0.0006	1000000 +	1000	10000

[a]The plus sign (+) means "greater than."

Table C-84
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Diuron [1] Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	---	---	---	---
VEGETATION CONTACT				
HIKER	---	---	---	---
PICKER	---	---	---	---
DRINKING WATER	---	---	---	---
EATING BERRIES	---	---	---	---
EATING VEGETS.	---	---	---	---
EATING DEER	---	---	---	---
EATING BIRD	---	---	---	---
EATING FISH	---	---	---	---
For Combined Routes of Exposure				
HIKER	---	---	---	---
BERRY PICKER	---	---	---	---
HUNTER	---	---	---	---
FISHERMAN	---	---	---	---
RESIDENT	---	---	---	---

[1]Scenario is inapplicable

Table C-85
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Diuron Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0010	1000000 +	610	6100
HIKER	0.0000	1000000 +	42000	420000
PICKER	0.0026	1000000 +	240	2400
DRINKING WATER	0.0006	1000000 +	1100	11000
EATING BERRIES	0.0011	1000000 +	570	5700
EATING VEGETS.	0.0022	1000000 +	280	2800
EATING DEER	0.0001	1000000 +	4300	43000
EATING BIRD	0.0005	1000000 +	1400	14000
EATING FISH	0.0046	820000	140	1400
For Combined Routes of Exposure				
HIKER	0.0016	1000000 +	390	3900
BERRY PICKER	0.0054	700000	120	1200
HUNTER	0.0022	1000000 +	280	2800
FISHERMAN	0.0062	600000	100	1000
RESIDENT	0.0038	980000	160	1600

[a]The plus sign (+) means "greater than."

Table C-86
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Diuron Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0010	1000000 +	650	6500
HIKER	0.0000	1000000 +	45000	450000
PICKER	0.0025	1000000 +	250	2500
DRINKING WATER	0.0008	1000000 +	780	7800
EATING BERRIES	0.0012	1000000 +	500	5000
EATING VEGETS.	0.0025	1000000 +	250	2500
EATING DEER	0.0002	1000000 +	4000	40000
EATING BIRD	0.0004	1000000 +	1400	14000
EATING FISH	0.0064	590000	98	980
For Combined Routes of Exposure				
HIKER	0.0018	1000000 +	350	3500
BERRY PICKER	0.0055	690000	110	1100
HUNTER	0.0024	1000000 +	260	2600
FISHERMAN	0.0081	460000	77	770
RESIDENT	0.0043	880000	150	1500

[a]The plus sign (+) means "greater than."

Table C-87
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Fosamine Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	1000000	1000000 +
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0049	1000000 +	5100	150000
DRINKING WATER	0.0028	1000000 +	8800	270000
EATING BERRIES	0.0016	1000000 +	15000	460000
EATING VEGETS.	0.0032	1000000 +	7700	230000
EATING DEER	0.0002	1000000 +	110000	1000000 +
EATING BIRD	0.0008	1000000 +	30000	910000
EATING FISH	0.0011	1000000 +	22000	660000
For Combined Routes of Exposure				
HIKER	0.0029	1000000 +	9800	260000
BERRY PICKER	0.0093	1000000 +	2700	80000
HUNTER	0.0039	1000000 +	6400	190000
FISHERMAN	0.0040	1000000 +	6300	190000
RESIDENT	0.0061	1000000 +	4100	120000

[a]The plus sign (+) means "greater than."

Table C-88
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Fosamine Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0003	1000000 +	94000	1000000 +
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0011	1000000 +	24000	710000
DRINKING WATER	0.0002	1000000 +	100000	1000000 +
EATING BERRIES	0.0005	1000000 +	54000	1000000 +
EATING VEGETS.	0.0009	1000000 +	27000	820000
EATING DEER	0.0001	1000000 +	420000	1000000 +
EATING BIRD	0.0002	1000000 +	140000	1000000 +
EATING FISH	0.0001	1000000 +	250000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0005	1000000 +	48000	1000000 +
BERRY PICKER	0.0020	1000000 +	12000	370000
HUNTER	0.0008	1000000 +	33000	980000
FISHERMAN	0.0006	1000000 +	40000	1000000 +
RESIDENT	0.0014	1000000 +	17000	520000

[a]The plus sign (+) means "greater than."

Table C-89
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Fosamine Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0001	1000000+	360000	1000000+
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0004	1000000+	67000	1000000+
DRINKING WATER	0.0001	1000000+	170000	1000000+
EATING BERRIES	0.0002	1000000+	120000	1000000+
EATING VEGETS.	0.0004	1000000+	61000	1000000+
EATING DEER	0.0000	1000000+	980000	1000000+
EATING BIRD	0.0001	1000000+	370000	1000000+
EATING FISH	0.0001	1000000+	420000	1000000+
For Combined Routes of Exposure				
HIKER	0.0002	1000000+	110000	1000000+
BERRY PICKER	0.0008	1000000+	31000	940000
HUNTER	0.0003	1000000+	80000	1000000+
FISHERMAN	0.0003	1000000+	90000	1000000+
RESIDENT	0.0006	1000000+	40000	1000000+

[a]The plus sign (+) means "greater than."

Table C-90
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Fosamine Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0509	480000	490	15000
HIKER	0.0007	1000000+	34000	1000000
PICKER	0.1313	190000	190	5700
DRINKING WATER	0.0380	640000	660	20000
EATING BERRIES	0.0313	780000	800	24000
EATING VEGETS.	0.0625	390000	400	12000
EATING DEER	0.0049	1000000+	5100	150000
EATING BIRD	0.0213	1000000+	1200	35000
EATING FISH	0.0152	1000000+	1600	49000
For Combined Routes of Exposure				
HIKER	0.0897	270000	280	8400
BERRY PICKER	0.2516	97000	99	3000
HUNTER	0.1159	210000	220	6500
FISHERMAN	0.1049	230000	240	7100
RESIDENT	0.1523	160000	160	4900

[a]The plus sign (+) means "greater than."

Table C-91
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Fosamine Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0020	1000000+	13000	380000
HIKER	0.0000	1000000+	880000	1000000+
PICKER	0.0051	1000000+	4900	150000
DRINKING WATER	0.0011	1000000+	23000	680000
EATING BERRIES	0.0021	1000000+	12000	350000
EATING VEGETS.	0.0042	1000000+	5900	180000
EATING DEER	0.0003	1000000+	90000	1000000+
EATING BIRD	0.0009	1000000+	29000	860000
EATING FISH	0.0004	1000000+	57000	1000000+
For Combined Routes of Exposure				
HIKER	0.0031	1000000+	8100	240000
BERRY PICKER	0.0103	1000000+	2400	73000
HUNTER	0.0043	1000000+	59001	80000
FISHERMAN	0.0035	1000000+	7100	210000
RESIDENT	0.0073	1000000+	3400	100000

[a]The plus sign (+) means "greater than."

Table C-92
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Fosamine Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (24400.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0006	1000000+	39000	1000000+
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0017	1000000+	15000	450000
DRINKING WATER	0.0005	1000000+	47000	1000000+
EATING BERRIES	0.0008	1000000+	30000	900000
EATING VEGETS.	0.0017	1000000+	15000	450000
EATING DEER	0.0001	1000000+	240000	1000000+
EATING BIRD	0.0003	1000000+	85000	1000000+
EATING FISH	0.0002	1000000+	120000	1000000+
For Combined Routes of Exposure				
HIKER	0.0012	1000000+	21000	630000
BERRY PICKER	0.0037	1000000+	6800	210000
HUNTER	0.0016	1000000+	16000	470000
FISHERMAN	0.0014	1000000+	18000	540000
RESIDENT	0.0028	1000000+	8800	260000

[a]The plus sign (+) means "greater than."

Table C-93
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Glyphosate Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	1000000 +	620000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0032	1000000 +	9200	3100
DRINKING WATER	0.0019	1000000 +	16000	5300
EATING BERRIES	0.0011	1000000 +	28000	9300
EATING VEGETS.	0.0022	1000000 +	14000	4600
EATING DEER	0.0002	1000000 +	190000	65000
EATING BIRD	0.0005	1000000 +	55000	18000
EATING FISH	0.0008	1000000 +	40000	13000
For Combined Routes of Exposure				
HIKER	0.0019	1000000 +	16000	5300
BERRY PICKER	0.0062	690000	4800	1600
HUNTER	0.0026	1000000 +	12000	3800
FISHERMAN	0.0027	1000000 +	11000	3800
RESIDENT	0.0041	1000000 +	7400	2500

[a]The plus sign (+) means "greater than."

Table C-94
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Glyphosate Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0001	1000000 +	220000	75000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0005	1000000 +	57000	19000
DRINKING WATER	0.0001	1000000 +	240000	80000
EATING BERRIES	0.0002	1000000 +	130000	44000
EATING VEGETS.	0.0005	1000000 +	65000	22000
EATING DEER	0.0000	1000000 +	1000000	330000
EATING BIRD	0.0001	1000000 +	330000	110000
EATING FISH	0.0000	1000000 +	600000	200000
For Combined Routes of Exposure				
HIKER	0.0003	1000000 +	120000	38000
BERRY PICKER	0.0010	1000000 +	30000	9800
HUNTER	0.0004	1000000 +	79000	26000
FISHERMAN	0.0003	1000000 +	97000	32000
RESIDENT	0.0007	1000000 +	42000	14000

[a]The plus sign (+) means "greater than."

Table C-95
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Glyphosate Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	870000	290000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0002	1000000 +	160000	54000
DRINKING WATER	0.0001	1000000 +	400000	130000
EATING BERRIES	0.0001	1000000 +	290000	98000
EATING VEGETS.	0.0002	1000000 +	150000	49000
EATING DEER	0.0000	1000000 +	1000000 +	780000
EATING BIRD	0.0000	1000000 +	890000	300000
EATING FISH	0.0000	1000000 +	1000000	340000
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	270000	91000
BERRY PICKER	0.0004	1000000 +	75000	25000
HUNTER	0.0002	1000000 +	190000	64000
FISHERMAN	0.0001	1000000 +	220000	72000
RESIDENT	0.0003	1000000 +	96000	32000

[a]The plus sign (+) means "greater than."

Table C-96
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Glyphosate Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0212	200000	1400	470
HIKER	0.0003	1000000 +	99000	33000
PICKER	0.0547	79000	550	180
DRINKING WATER	0.0159	270000	1900	630
EATING BERRIES	0.0130	330000	2300	770
EATING VEGETS.	0.0261	170000	1200	380
EATING DEER	0.0020	1000000 +	15000	4900
EATING BIRD	0.0089	490000	3400	1100
EATING FISH	0.0063	680000	4700	1600
For Combined Routes of Exposure				
HIKER	0.0374	120000	800	270
BERRY PICKER	0.1048	41000	290	95
HUNTER	0.0483	89000	620	210
FISHERMAN	0.0437	99000	690	230
RESIDENT	0.0634	68000	470	160

[a]The plus sign (+) means "greater than."

Table C-97
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Glyphosate Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0009	1000000 +	35000	12000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	810000
PICKER	0.0022	1000000 +	14000	4500
DRINKING WATER	0.0005	1000000 +	63000	21000
EATING BERRIES	0.0009	1000000 +	33000	11000
EATING VEGETS.	0.0018	1000000 +	16000	5400
EATING DEER	0.0001	1000000 +	250000	83000
ATING BIRD	0.0004	1000000 +	79000	26000
EATING FISH	0.0002	1000000 +	160000	52000
For Combined Routes of Exposure				
HIKER	0.0013	1000000 +	22000	7400
BERRY PICKER	0.0045	970000	6700	2200
HUNTER	0.0018	1000000 +	16000	5400
FISHERMAN	0.0015	1000000 +	20000	6500
RESIDENT	0.0032	1000000 +	9400	3100

[a]The plus sign (+) means "greater than."

Table C-98
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Glyphosate Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0003	1000000 +	100000	33000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0008	1000000 +	38000	13000
DRINKING WATER	0.0002	1000000 +	120000	40000
EATING BERRIES	0.0004	1000000 +	77000	26000
EATING VEGETS.	0.0008	1000000 +	38000	13000
EATING DEER	0.0000	1000000 +	610000	200000
EATING BIRD	0.0001	1000000 +	220000	73000
EATING FISH	0.0001	1000000 +	300000	100000
For Combined Routes of Exposure				
HIKER	0.0006	1000000 +	54000	18000
BERRY PICKER	0.0017	1000000 +	18000	5900
HUNTER	0.0007	1000000 +	41000	14000
FISHERMAN	0.0007	1000000 +	46000	15000
RESIDENT	0.0013	1000000 +	23000	7500

[a]The plus sign (+) means "greater than."

Table C-99
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Hexazinone Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	500000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0041	420000	2500	31000
DRINKING WATER	0.0024	720000	4200	53000
EATING BERRIES	0.0013	1000000 +	7400	93000
EATING VEGETS.	0.0027	630000	3700	46000
EATING DEER	0.0002	1000000 +	52000	650000
EATING BIRD	0.0007	1000000 +	15000	180000
EATING FISH	0.0009	1000000 +	11000	130000
For Combined Routes of Exposure				
HIKER	0.0024	710000	4200	53000
BERRY PICKER	0.0078	220000	1300	16000
HUNTER	0.0033	520000	3100	38000
FISHERMAN	0.0033	510000	3000	38000
RESIDENT	0.0051	330000	2000	25000

[a]The plus sign (+) means "greater than."

Table C-100
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Hexazinone Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	100000	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0004	1000000 +	25000	320000
DRINKING WATER	0.0001	1000000 +	110000	1000000 +
EATING BERRIES	0.0002	1000000 +	58000	730000
EATING VEGETS.	0.0003	1000000 +	29000	360000
EATING DEER	0.0000	1000000 +	450000	1000000 +
EATING BIRD	0.0001	1000000 +	150000	1000000 +
EATING FISH	0.0000	1000000 +	270000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0002	1000000 +	52000	640000
BERRY PICKER	0.0008	1000000 +	13000	160000
HUNTER	0.0003	1000000 +	35000	440000
FISHERMAN	0.0002	1000000 +	43000	540000
RESIDENT	0.0005	1000000 +	19000	230000

[a]The plus sign (+) means "greater than."

Table C-101
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Hexazinone Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (169.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	230000	1000000 +
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0002	1000000 +	43000	540000
DRINKING WATER	0.0001	1000000 +	110000	1000000 +
EATING BERRIES	0.0001	1000000 +	78000	980000
EATING VEGETS.	0.0003	1000000 +	39000	490000
EATING DEER	0.0000	1000000 +	630000	1000000 +
EATING BIRD	0.0000	1000000 +	240000	1000000 +
EATING FISH	0.0000	1000000 +	270000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	73000	910000
BERRY PICKER	0.0005	1000000 +	20000	250000
HUNTER	0.0002	1000000 +	51000	640000
FISHERMAN	0.0002	1000000 +	57000	720000
RESIDENT	0.0004	1000000 +	25000	320000

[a]The plus sign (+) means "greater than."

Table C-102
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Hexazinone Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0127	130000	790	9800
HIKER	0.0002	1000000 +	55000	680000
PICKER	0.0026	51000	300	3800
DRINKING WATER	0.0095	180000	1100	13000
EATING BERRIES	0.0078	220000	1300	16000
EATING VEGETS.	0.0156	110000	640	8000
EATING DEER	0.0012	1000000 +	8200	100000
EATING BIRD	0.0053	320000	1900	23000
EATING FISH	0.0038	440000	2600	33000
For Combined Routes of Exposure				
HIKER	0.0224	75000	450	5600
BERRY PICKER	0.0829	27000	160	2000
HUNTER	0.0280	58000	350	4300
FISHERMAN	0.0262	64000	380	4800
RESIDENT	0.0381	44000	260	3300

[a]The plus sign (+) means "greater than."

Table C-103
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Hexazinone Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0005	1000000 +	19000	240000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0013	1000000 +	7500	94000
DRINKING WATER	0.0003	1000000 +	35000	440000
EATING BERRIES	0.0006	1000000 +	18000	230000
EATING VEGETS.	0.0011	1000000 +	9000	110000
EATING DEER	0.0001	1000000 +	140000	1000000 +
EATING BIRD	0.0002	1000000 +	44000	550000
EATING FISH	0.0001	1000000 +	87000	1000000 +
For Combined Routes of Exposure				
HIKER	0.0008	1000000 +	12000	150000
BERRY PICKER	0.0027	630000	3700	47000
HUNTER	0.0011	1000000 +	9000	110000
FISHERMAN	0.0009	1000000 +	11000	140000
RESIDENT	0.0019	880000	5200	65000

[a]The plus sign (+) means "greater than."

Table C-104
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Hexazinone Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0004	1000000 +	28000	350000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0009	1000000 +	11000	130000
DRINKING WATER	0.0003	1000000 +	33000	420000
EATING BERRIES	0.0005	1000000 +	21000	270000
EATING VEGETS.	0.0009	1000000 +	11000	130000
EATING DEER	0.0001	1000000 +	170000	1000000 +
EATING BIRD	0.0002	1000000 +	61000	760000
EATING FISH	0.0001	1000000 +	84000	1000000
For Combined Routes of Exposure				
HIKER	0.0007	1000000 +	15000	190000
BERRY PICKER	0.0021	820000	4900	61000
HUNTER	0.0009	1000000 +	11000	140000
FISHERMAN	0.0008	1000000 +	13000	160000
RESIDENT	0.0016	1000000 +	6300	78000

[a]The plus sign (+) means "greater than."

Table C-105
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Picloram Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000+	1000000+	1000000+
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0001	1000000+	90000	640000
DRINKING WATER	0.0009	1000000+	7400	53000
EATING BERRIES	0.0005	1000000+	13000	93000
EATING VEGETS.	0.0011	1000000+	6500	46000
EATING DEER	0.0001	1000000+	96000	680000
EATING BIRD	0.0002	1000000+	29000	200000
EATING FISH	0.0004	1000000+	19000	130000
For Combined Routes of Exposure				
HIKER	0.0009	1000000+	7400	53000
BERRY PICKER	0.0016	1000000+	4500	32000
HUNTER	0.0013	1000000+	5600	40000
FISHERMAN	0.0013	1000000+	5300	38000
RESIDENT	0.0020	1000000+	3500	25000

[a]The plus sign (+) means "greater than."

Table C-106
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Picloram Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000+	1000000+	1000000+
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0000	1000000+	410000	1000000+
DRINKING WATER	0.0001	1000000+	84000	600000
EATING BERRIES	0.0002	1000000+	46000	330000
EATING VEGETS.	0.0003	1000000+	23000	160000
EATING DEER	0.0000	1000000+	370000	1000000+
EATING BIRD	0.0001	1000000+	130000	910000
EATING FISH	0.0000	1000000+	210000	1000000+
For Combined Routes of Exposure				
HIKER	0.0001	1000000+	80000	570000
BERRY PICKER	0.0003	1000000+	27000	190000
HUNTER	0.0002	1000000+	43000	310000
FISHERMAN	0.0001	1000000+	58000	420000
RESIDENT	0.0004	1000000+	18000	130000

[a]The plus sign (+) means "greater than."

Table C-107
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Picloram Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000+	1000000+	1000000+
HIKER	0.0000	1000000+	1000000+	1000000+
PICKER	0.0000	1000000+	1000000+	1000000+
DRINKING WATER	0.0000	1000000+	190000	1000000+
EATING BERRIES	0.0001	1000000+	140000	980000
EATING VEGETS.	0.0001	1000000+	68000	490000
EATING DEER	0.0000	1000000+	1000000+	1000000+
EATING BIRD	0.0000	1000000+	460000	1000000+
EATING FISH	0.0000	1000000+	470000	1000000+
For Combined Routes of Exposure				
HIKER	0.0000	1000000+	180000	1000000+
BERRY PICKER	0.0001	1000000+	75000	530000
HUNTER	0.0001	1000000+	120000	840000
FISHERMAN	0.0001	1000000+	130000	940000
RESIDENT	0.0001	1000000+	50000	360000

[a]The plus sign (+) means "greater than."

Table C-108
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Picloram Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0010	1000000+	6900	49000
HIKER	0.0000	1000000+	480000	1000000+
PICKER	0.0026	1000000+	2700	19000
DRINKING WATER	0.0159	520000	440	3200
EATING BERRIES	0.0130	630000	540	3800
EATING VEGETS.	0.0261	310000	270	1900
EATING DEER	0.0019	1000000+	3700	26000
EATING BIRD	0.0079	1000000	890	6300
EATING FISH	0.0063	1000000+	1100	7900
For Combined Routes of Exposure				
HIKER	0.0169	490000	410	3000
BERRY PICKER	0.0325	250000	220	1500
HUNTER	0.0267	310000	260	1900
FISHERMAN	0.0232	350000	300	2200
RESIDENT	0.0429	190000	160	1200

[a]The plus sign (+) means "greater than."

Table C-109
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Picloram Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	210000	1000000 +
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0001	1000000 +	83000	590000
DRINKING WATER	0.0004	1000000 +	18000	130000
EATING BERRIES	0.0007	1000000 +	9500	68000
EATING VEGETS.	0.0015	1000000 +	4700	34000
EATING DEER	0.0001	1000000 +	76000	540000
EATING BIRD	0.0003	1000000 +	26000	180000
EATING FISH	0.0002	1000000 +	46000	330000
For Combined Routes of Exposure				
HIKER	0.0004	1000000 +	17000	120000
BERRY PICKER	0.0012	1000000 +	5700	40000
HUNTER	0.0008	1000000 +	9000	64000
FISHERMAN	0.0006	1000000 +	12000	88000
RESIDENT	0.0019	1000000 +	3700	26000

[a]The plus sign (+) means "greater than."

Table C-110
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Picloram Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	1000000 +	1000000 +
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0000	1000000 +	470000	1000000 +
DRINKING WATER	0.0001	1000000 +	70000	500000
EATING BERRIES	0.0002	1000000 +	45000	320000
EATING VEGETS.	0.0003	1000000 +	23000	160000
EATING DEER	0.0000	1000000 +	370000	1000000 +
EATING BIRD	0.0000	1000000 +	140000	1000000
EATING FISH	0.0000	1000000 +	180000	1000000 +
For Combined Routes of Exposure:				
HIKER	0.0001	1000000 +	66000	470000
BERRY PICKER	0.0003	1000000 +	25000	180000
HUNTER	0.0002	1000000 +	40000	290000
FISHERMAN	0.0001	1000000 +	48000	340000
RESIDENT	0.0004	1000000 +	17000	120000

[a]The plus sign (+) means "greater than."

Table C-111
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Simazine Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	160000	160000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0065	770000	770	770
DRINKING WATER	0.0038	1000000 +	1300	1300
EATING BERRIES	0.0022	1000000 +	2300	2300
EATING VEGETS.	0.0043	1000000 +	1200	1200
EATING DEER	0.0003	1000000 +	16000	16000
EATING BIRD	0.0011	1000000 +	4500	4500
EATING FISH	0.0015	1000000 +	3300	3300
For Combined Routes of Exposure				
HIKER	0.0038	1000000 +	1300	1300
BERRY PICKER	0.0124	400000	400	400
HUNTER	0.0052	960000	960	960
FISHERMAN	0.0053	940000	940	940
RESIDENT	0.0081	620000	620	620

[a]The plus sign (+) means "greater than."

Table C-112
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Simazine Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0002	1000000 +	28000	28000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0007	1000000 +	7100	7100
DRINKING WATER	0.0002	1000000 +	30000	30000
EATING BERRIES	0.0003	1000000 +	16000	16000
EATING VEGETS.	0.0006	1000000 +	8200	8200
EATING DEER	0.0000	1000000 +	130000	130000
EATING BIRD	0.0001	1000000 +	41000	41000
EATING FISH	0.0001	1000000 +	75000	75000
For Combined Routes of Exposure				
HIKER	0.0003	1000000 +	14000	14000
BERRY PICKER	0.0014	1000000 +	3700	3700
HUNTER	0.0005	1000000 +	9800	9800
FISHERMAN	0.0004	1000000 +	12000	12000
RESIDENT	0.0010	1000000 +	5200	5200

[a]The plus sign (+) means "greater than."

Table C-113
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Simazine Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	140000	140000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0002	1000000 +	27000	27000
DRINKING WATER	0.0001	1000000 +	67000	67000
EATING BERRIES	0.0001	1000000 +	49000	49000
EATING VEGETS.	0.0002	1000000 +	24000	24000
EATING DEER	0.0000	1000000 +	390000	390000
EATING BIRD	0.0000	1000000 +	150000	150000
EATING FISH	0.0000	1000000 +	170000	170000
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	46000	46000
BERRY PICKER	0.0004	1000000 +	13000	13000
HUNTER	0.0002	1000000 +	32000	32000
FISHERMAN	0.0001	1000000 +	36000	36000
RESIDENT	0.0003	1000000 +	16000	16000

[a]The plus sign (+) means "greater than."

Table C-114
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Simazine Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0212	240000	240	240
HIKER	0.0003	1000000 +	16000	16000
PICKER	0.0547	91000	91	91
DRINKING WATER	0.0159	320000	320	320
EATING BERRIES	0.0130	380000	380	380
EATING VEGETS.	0.0261	190000	190	190
EATING DEER	0.0020	1000000 +	2500	2500
EATING BIRD	0.0089	560000	560	560
EATING FISH	0.0063	790000	790	790
For Combined Routes of Exposure				
HIKER	0.0374	130000	130	130
BERRY PICKER	0.1046	48000	48	48
HUNTER	0.0483	100000	100	100
FISHERMAN	0.0437	110000	110	110
RESIDENT	0.0634	79000	79	79

[a]The plus sign (+) means "greater than."

Table C-115
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Simazine Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0008	1000000 +	6300	6300
HIKER	0.0000	1000000 +	440000	440000
PICKER	0.0020	1000000 +	2500	2500
DRINKING WATER	0.0004	1000000 +	11000	11000
EATING BERRIES	0.0008	1000000 +	5900	5900
EATING VEGETS.	0.0017	1000000 +	2900	2900
EATING DEER	0.0001	1000000 +	45000	45000
EATING BIRD	0.0004	1000000 +	14000	14000
EATING FISH	0.0002	1000000 +	28000	28000
For Combined Routes of Exposure				
HIKER	0.0012	1000000 +	4000	4000
BERRY PICKER	0.0041	1000000 +	1200	1200
HUNTER	0.0017	1000000 +	2900	2900
FISHERMAN	0.0014	1000000 +	3500	3500
RESIDENT	0.0029	1000000 +	1700	1700

[a]The plus sign (+) means "greater than."

Table C-116
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Simazine Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0003	1000000 +	18000	18000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0007	1000000 +	7000	7000
DRINKING WATER	0.0002	1000000 +	22000	22000
EATING BERRIES	0.0004	1000000 +	14000	14000
EATING VEGETS.	0.0007	1000000 +	7000	7000
EATING DEER	0.0000	1000000 +	110000	110000
EATING BIRD	0.0001	1000000 +	39000	39000
EATING FISH	0.0001	1000000 +	55000	55000
For Combined Routes of Exposure				
HIKER	0.0005	1000000 +	9800	9800
BERRY PICKER	0.0016	1000000 +	3200	3200
HUNTER	0.0007	1000000 +	7300	7300
FISHERMAN	0.0006	1000000 +	8300	8300
RESIDENT	0.0012	1000000 +	4100	4100

[a]The plus sign (+) means "greater than."

Table C-117
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Tebuthiuron Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (644.0)	SYSTEMIC NOEL (12.50)	REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	1000000 +	1000000 +
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0016	400000	7700	55000
DRINKING WATER	0.0009	680000	13000	96000
EATING BERRIES	0.0005	1000000 +	23000	170000
EATING VEGETS.	0.0011	600000	12000	83000
EATING DEER	0.0001	1000000 +	160000	1000000 +
EATING BIRD	0.0003	1000000 +	45000	330000
EATING FISH	0.0038	170000	3300	24000
For Combined Routes of Exposure				
HIKER	0.0010	680000	13000	95000
BERRY PICKER	0.0031	210000	4000	29000
HUNTER	0.0013	490000	9600	69000
FISHERMAN	0.0047	140000	2600	19000
RESIDENT	0.0020	320000	6200	44000

[a]The plus sign (+) means "greater than."

Table C-118
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Tebuthiuron Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (644.0)	SYSTEMIC NOEL (12.50)	REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0001	1000000 +	94000	670000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0005	1000000 +	24000	170000
DRINKING WATER	0.0001	1000000 +	100000	720000
EATING BERRIES	0.0002	1000000 +	54000	390000
EATING VEGETS.	0.0005	1000000 +	27000	200000
EATING DEER	0.0000	1000000 +	420000	1000000 +
EATING BIRD	0.0001	1000000 +	140000	980000
EATING FISH	0.0005	1000000 +	25000	180000
For Combined Routes of Exposure				
HIKER	0.0003	1000000 +	48000	350000
BERRY PICKER	0.0010	630000	12000	89000
HUNTER	0.0004	1000000 +	33000	240000
FISHERMAN	0.0008	860000	17000	120000
RESIDENT	0.0007	900000	17000	130000

[a]The plus sign (+) means "greater than."

Table C-119
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Tebuthiuron Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (644.0)	SYSTEMIC NOEL (12.50)	REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	330000	1000000 +
VEGETATION CONTACT				
IKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0002	1000000 +	61000	440000
DRINKING WATER	0.0001	1000000 +	150000	1000000 +
EATING BERRIES	0.0001	1000000 +	110000	800000
EATING VEGETS.	0.0002	1000000 +	56000	400000
EATING DEER	0.0000	1000000 +	890000	1000000 +
EATING BIRD	0.0000	1000000 +	340000	1000000 +
EATING FISH	0.0003	1000000 +	38000	270000
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	100000	750000
BERRY PICKER	0.0004	1000000 +	29000	210000
HUNTER	0.0002	1000000 +	73000	520000
FISHERMAN	0.0004	1000000 +	28000	200000
RESIDENT	0.0003	1000000 +	36000	260000

[a]The plus sign (+) means "greater than."

Table C-120
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Tebuthiuron Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	MARGIN OF SAFETY RELATIVE TO LD_{50} (644.0)	SYSTEMIC NOEL (12.50)	REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0255	25000	490	3500
VEGETATION CONTACT				
HIKER	0.0004	1000000 +	34000	250000
PICKER	0.0657	9800	190	1400
DRINKING WATER	0.0190	34000	660	4700
EATING BERRIES	0.0156	41000	800	5800
EATING VEGETS.	0.0313	21000	400	2900
EATING DEER	0.0024	260000	5100	37000
EATING BIRD	0.0107	60000	1200	8400
EATING FISH	0.0761	8500	160	1200
For Combined Routes of Exposure				
HIKER	0.0449	14000	280	2000
BERRY PICKER	0.1258	5100	99	720
HUNTER	0.0580	11000	220	1600
FISHERMAN	0.1209	5300	100	740
RESIDENT	0.0781	8500	160	1200

[a]The plus sign (+) means "greater than."

Table C-121
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Tebuthiuron Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (644.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (12.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0010	630000	12000	88000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	850000	1000000 +
PICKER	0.0026	240000	4700	34000
DRINKING WATER	0.0006	1000000 +	22000	160000
EATING BERRIES	0.0011	580000	11000	81000
EATING VEGETS.	0.0022	290000	5700	41000
EATING DEER	0.0001	1000000 +	86000	620000
EATING BIRD	0.0005	1000000 +	27000	200000
EATING FISH	0.0023	280000	5500	39000
For Combined Routes of Exposure				
HIKER	0.0016	400000	7700	56000
BERRY PICKER	0.0054	120000	2300	17000
HUNTER	0.0022	290000	5600	41000
FISHERMAN	0.0039	160000	3200	23000
RESIDENT	0.0038	170000	3300	24000

[a]The plus sign (+) means "greater than."

Table C-122
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Tebuthiuron Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (644.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (12.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0003	1000000 +	45000	330000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0007	910000	18000	130000
DRINKING WATER	0.0002	1000000 +	55000	390000
EATING BERRIES	0.0004	1000000 +	35000	250000
EATING VEGETS.	0.0007	900000	18000	130000
EATING DEER	0.0000	1000000 +	280000	1000000 +
EATING BIRD	0.0001	1000000 +	99000	710000
EATING FISH	0.0009	700000	14000	98000
For Combined Routes of Exposure				
HIKER	0.0005	1000000 +	25000	180000
BERRY PICKER	0.0016	410000	7900	57000
HUNTER	0.0007	950000	18000	130000
FISHERMAN	0.0014	450000	8800	63000
RESIDENT	0.0012	530000	10000	74000

[a]The plus sign (+) means "greater than."

Table C-123
Margins of Safety for Exposed Members of the Public For Aerial Routine-Realistic Scenario Triclopyr Sprayed on 40 acres by Helicopter

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0000	1000000 +	160000	620000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0032	190000	770	3100
DRINKING WATER	0.0019	330000	1300	5300
EATING BERRIES	0.0011	580000	2300	9300
EATING VEGETS.	0.0022	290000	1200	4600
EATING DEER	0.0002	1000000 +	16000	65000
EATING BIRD	0.0006	1000000 +	4500	18000
EATING FISH	0.0008	840000	3300	13000
For Combined Routes of Exposure				
HIKER	0.0019	330000	1300	5300
BERRY PICKER	0.0062	100000	400	1600
HUNTER	0.0026	240000	960	3800
FISHERMAN	0.0027	240000	940	3800
RESIDENT	0.0041	160000	620	2500

[a]The plus sign (+) means "greater than."

Table C-124
Margins of Safety for Exposed Members of the Public For Backpack Routine-Realistic Scenario Triclopyr Sprayed on 6 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0002	1000000 +	14000	56000
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	980000	1000000 +
PICKER	0.0007	890000	3600	14000
DRINKING WATER	0.0002	1000000 +	15000	60000
EATING BERRIES	0.0003	1000000 +	8200	33000
EATING VEGETS.	0.0006	1000000	4100	16000
EATING DEER	0.0000	1000000 +	63000	250000
EATING BIRD	0.0001	1000000 +	20000	82000
EATING FISH	0.0001	1000000 +	38000	150000
For Combined Routes of Exposure				
HIKER	0.0003	1000000 +	7200	29000
BERRY PICKER	0.0014	470000	1800	7400
HUNTER	0.0005	1000000 +	4900	20000
FISHERMAN	0.0004	1000000 +	6100	24000
RESIDENT	0.0010	660000	2600	10000

[a]The plus sign (+) means "greater than."

Table C-125
Margins of Safety for Exposed Members of the Public For Right-of-Way Routine-Realistic Scenario Triclopyr Sprayed on 12 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0000	1000000 +	72000	290000
HIKER	0.0000	1000000 +	1000000 +	1000000 +
PICKER	0.0002	1000000 +	13000	54000
DRINKING WATER	0.0001	1000000 +	34000	130000
EATING BERRIES	0.0001	1000000 +	24000	98000
EATING VEGETS.	0.0002	1000000 +	12000	49000
EATING DEER	0.0000	1000000 +	200000	780000
EATING BIRD	0.0000	1000000 +	74000	300000
EATING FISH	0.0000	1000000 +	84000	340000
For Combined Routes of Exposure				
HIKER	0.0001	1000000 +	23000	91000
BERRY PICKER	0.0004	1000000 +	6300	25000
HUNTER	0.0002	1000000 +	16000	64000
FISHERMAN	0.0001	1000000 +	18000	72000
RESIDENT	0.0003	1000000 +	8000	32000

[a]The plus sign (+) means "greater than."

Table C-126
Margins of Safety for Exposed Members of the Public For Aerial Routine-Worst Case Scenario Triclopyr Sprayed on 400 acres by Fixed Wing

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0340	19000	74	290
HIKER	0.0005	1000000 +	5100	21000
PICKER	0.0876	7200	29	110
DRINKING WATER	0.0254	25000	99	390
EATING BERRIES	0.0206	30000	120	480
EATING VEGETS.	0.0417	15000	60	240
EATING DEER	0.0033	190000	770	3100
EATING BIRD	0.0142	44000	180	700
EATING FISH	0.0101	62000	250	990
For Combined Routes of Exposure				
HIKER	0.0598	11000	42	170
BERRY PICKER	0.1677	3800	15	60
HUNTER	0.0773	8200	32	130
FISHERMAN	0.0700	9000	36	140
RESIDENT	0.1015	6200	25	99

[a]The plus sign (+) means "greater than."

Table C-127
Margins of Safety for Exposed Members of the Public For Backpack Routine-Worst Case Scenario Triclopyr Sprayed on 60 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0014	460000	1800	7300
HIKER	0.0000	1000000 +	130000	510000
PICKER	0.0035	180000	710	2800
DRINKING WATER	0.0008	820000	3300	13000
EATING BERRIES	0.0015	430000	1700	6800
EATING VEGETS.	0.0029	210000	850	3400
EATING DEER	0.0002	1000000 +	13000	52000
EATING BIRD	0.0006	1000000	4100	16000
EATING FISH	0.0003	1000000 +	8200	33000
For Combined Routes of Exposure				
HIKER	0.0022	290000	1200	4600
BERRY PICKER	0.0071	88000	350	1400
HUNTER	0.0030	210000	850	3400
FISHERMAN	0.0025	260000	1000	4100
RESIDENT	0.0051	120000	490	2000

[a]The plus sign (+) means "greater than."

Table C-128
Margins of Safety for Exposed Members of the Public For Right of Way Routine-Worst Case Scenario Triclopyr Sprayed on 40 acres

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY VEGETATION CONTACT	0.0005	1000000 +	5200	21000
HIKER	0.0000	1000000 +	360000	1000000 +
PICKER	0.0012	510000	2000	8100
DRINKING WATER	0.0004	1000000 +	6300	25000
EATING BERRIES	0.0006	1000000	4000	16000
EATING VEGETS.	0.0012	510000	2000	8100
EATING DEER	0.0001	1000000 +	32000	130000
EATING BIRD	0.0002	1000000 +	11000	45000
EATING FISH	0.0002	1000000 +	16000	63000
For Combined Routes of Exposure				
HIKER	0.0009	710000	2800	11000
BERRY PICKER	0.0027	230000	910	3700
HUNTER	0.0012	530000	2100	8400
FISHERMAN	0.0010	600000	2400	9600
RESIDENT	0.0021	300000	1200	4700

[a]The plus sign (+) means "greater than."

Margins of Safety for Doses to the Public from Accidental Spraying

Table C-129
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Amitrole

	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.03)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.00)
For Single Route of Exposure				
DERMAL SPRAY	0.0033	1000000 +	7.5	1500
VEGETATION CONTACT				
HIKER	0.0000	1000000 +	520	100000
PICKER	0.0066	470000	2.9	580
DRINKING WATER	0.1174	35000	-4.7	43
EATING BERRIES	0.0932	44000	-3.7	54
EATING VEGETS.	0.1935	21000	-7.7	26
EATING DEER	0.0187	220000	1.3	270
EATING BIRD	0.1161	35000	-4.6	43
EATING FISH	0.0470	87000	-1.9	110
For Combined Routes of Exposure:				
HIKER	0.1208	34000	-4.8	41
BERRY PICKER	0.2225	18000	-8.9	22
HUNTER	0.2556	16000	-10	20
FISHERMAN	0.1677	24000	-6.7	30
RESIDENT	0.3143	13000	-13	16

[a]The plus sign (+) means "greater than."

Table C-130
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Asulam

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL SPRAY	0.2085	19000	240	240
VEGETATION CONTACT				
HIKER	0.0030	1000000 +	17000	17000
PICKER	0.5376	7400	93	93
DRINKING WATER	0.0734	55000	680	680
EATING BERRIES	0.0582	69000	860	860
EATING VEGETS.	0.1210	33000	410	410
EATING DEER	0.0131	310000	3800	3800
EATING BIRD	0.0827	48000	600	600
EATING FISH	0.0293	140000	1700	1700
For Combined Routes of Exposure:				
HIKER	0.2849	14000	180	180
BERRY PICKER	0.5777	4600	57	57
HUNTER	0.3807	11000	130	130
FISHERMAN	0.3142	13000	160	160
RESIDENT	0.4059	9900	120	120

[a]The plus sign (+) means "greater than."

Table C-131
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Atrazine

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
For Single Route of Exposure				
DERMAL SPRAY	0.3545	5300	10	280
VEGETATION CONTACT				
HIKER	0.0051	370000	730	20000
PICKER	0.9139	2000	4.0	110
DRINKING WATER	0.1247	15000	30	800
EATING BERRIES	0.0990	19000	37	1000
EATING VEGETS.	0.2056	9100	18	490
EATING DEER	0.0222	84000	170	4500
EATING BIRD	0.1406	13000	26	710
EATING FISH	0.2494	7500	15	400
For Combined Routes of Exposure				
HIKER	0.4843	3900	7.6	210
BERRY PICKER	1.4922	1300	2.5	67
HUNTER	0.6471	2900	5.7	150
FISHERMAN	0.7337	2500	5.0	140
RESIDENT	0.6900	2700	5.4	140

Table C-132
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Bromacil

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
For Single Route of Exposure				
DERMAL SPRAY	0.4171	9600	15	19
VEGETATION CONTACT				
HIKER	0.0060	670000	1000	1300
PICKER	1.0752	3700	5.8	7.4
DRINKING WATER	0.1467	27000	43	54
EATING BERRIES	0.1165	34000	54	68
EATING VEGETS.	0.2419	17000	26	33
EATING DEER	0.0261	150000	240	300
EATING BIRD	0.1654	24000	38	48
EATING FISH	0.0587	68000	110	130
For Combined Routes of Exposure:				
HIKER	0.5698	7000	11	14
BERRY PICKER	1.7555	2300	3.6	4.5
HUNTER	0.7613	5300	8.2	10
FISHERMAN	0.8265	6400	9.9	13
RESIDENT	0.8117	4900	7.7	9.6

Table C-133
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with 2,4-D

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (25.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.1026	3700	9.7	240
VEGETATION CONTACT				
HIKER	0.0015	250000	680	17000
PICKER	0.2645	1400	3.8	95
DRINKING WATER	0.0602	6200	17	420
EATING BERRIES	0.0478	7900	21	520
EATING VEGETS.	0.0992	3800	10	250
EATING DEER	0.0103	37000	97	2400
EATING BIRD	0.0645	5800	16	390
EATING FISH	0.0241	16000	42	1000
For Combined Routes of Exposure				
HIKER	0.1642	2300	6.1	150
BERRY PICKER	0.4750	790	2.1	53
HUNTER	0.2390	1600	42	100
FISHERMAN	0.1883	2000	53	130
RESIDENT	0.2634	1400	3.8	95

Table C-134
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with 2,4-DP

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.1335	4000	37	47
VEGETATION CONTACT				
HIKER	0.0019	280000	2600	3300
PICKER	0.3441	1500	15	18
DRINKING WATER	0.0734	7300	68	85
EATING BERRIES	0.0582	9100	86	110
EATING VEGETS.	0.1210	4400	41	52
EATING DEER	0.0126	42000	400	500
EATING BIRD	0.0790	6700	63	79
EATING FISH	0.0293	18000	170	210
For Combined Routes of Exposure:				
HIKER	0.2087	2500	24	30
BERRY PICKER	0.6091	870	8.2	10
HUNTER	0.3003	1800	17	21
FISHERMAN	0.2381	2200	21	26
RESIDENT	0.3297	1600	15	19

Table C-135
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Dalapon

	EXPOSURE (MG/KG/DAY)	LD_{50} (7577.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (15.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (300.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.4171	18000	36	720
VEGETATION CONTACT				
HIKER	0.0060	1000000 +	2500	50000
PICKER	1.0752	7000	14	280
DRINKING WATER	0.1467	52000	100	2000
EATING BERRIES	0.1165	65000	130	2600
EATING VEGETS.	0.2419	31000	62	1200
EATING DEER	0.0261	290000	570	11000
EATING BIRD	0.1654	46000	91	1800
EATING FISH	0.0587	130000	260	5100
For Combined Routes of Exposure				
HIKER	0.5698	13000	26	530
BERRY PICKER	1.7555	4300	8.5	170
HUNTER	0.7613	10000	20	390
FISHERMAN	0.6265	12000	24	480
RESIDENT	0.8117	9300	18	370

[a]The plus sign (+) means "greater than."

Table C-136
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Dicamba

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (2.50)
For Single Route of Exposure				
DERMAL, SPRAY	0.0834	9100	300	30
VEGETATION CONTACT				
HIKER	0.0012	630000	21000	2100
PICKER	0.2150	3500	120	12
DRINKING WATER	0.0587	13000	430	43
EATING BERRIES	0.0466	16000	540	54
EATING VEGETS.	0.0968	7800	260	26
EATING DEER	0.0099	76000	2500	250
EATING BIRD	0.0621	12000	400	40
EATING FISH	0.0235	32000	1100	110
For Combined Routes of Exposure				
HIKER	0.1433	5300	170	17
BERRY PICKER	0.4037	1900	62	6.2
HUNTER	0.2153	3500	120	12
FISHERMAN	0.1668	4500	150	15
RESIDENT	0.2401	3200	100	10

Table C-137
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Diuron

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
For Single Route of Exposure				
DERMAL, SPRAY	0.6573	5600	-1.1	9.4
VEGETATION CONTACT				
HIKER	0.0096	390000	65	650
PICKER	1.7203	2200	-2.8	3.6
DRINKING WATER	0.2348	16000	2.7	27
EATING BERRIES	0.1864	20000	3.4	34
EATING VEGETS.	0.3871	9700	1.6	16
EATING DEER	0.0418	90000	15	150
EATING BIRD	0.2647	14000	2.4	24
EATING FISH	1.8780	2000	-3.0	3.3
For Combined Routes of Exposure				
HIKER	0.9117	4100	-1.5	6.9
BERRY PICKER	2.8068	1300	-4.5	2.2
HUNTER	1.2181	3100	-1.9	5.1
FISHERMAN	2.7897	1300	-4.5	2.2
RESIDENT	1.2987	2900	-2.1	4.8

Table C-138
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Fosamine

	EXPOSURE (MG/KG/DAY)	LD_{50} (2440.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.5005	49000	50	1500
VEGETATION CONTACT				
HIKER	0.0072	1000000+	3500	100000
PICKER	1.2992	19000	19	580
DRINKING WATER	0.1761	140000	140	4300
EATING BERRIES	0.1398	170000	180	5400
EATING VEGETS.	0.2903	84000	86	2600
EATING DEER	0.0313	780000	800	24000
EATING BIRD	0.1985	120000	130	3800
EATING FISH	0.0704	350000	360	11000
For Combined Routes of Exposure				
HIKER	0.6836	36000	37	1100
BERRY PICKER	2.1056	12000	12	380
HUNTER	0.9136	27000	27	820
FISHERMAN	0.7542	32000	33	990
RESIDENT	0.9741	25000	26	770

[a]The plus sign (+) means "greater than."

Table C-139
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Glyphosate

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.2065	21000	140	48
VEGETATION CONTACT				
HIKER	0.0030	1000000+	10000	3300
PICKER	0.5376	8000	56	19
DRINKING WATER	0.0734	59000	410	140
EATING BERRIES	0.0582	74000	520	170
EATING VEGETS.	0.1210	36000	250	83
EATING DEER	0.0131	330000	2300	770
EATING BIRD	0.0827	52000	360	120
EATING FISH	0.0293	150000	1000	340
For Combined Routes of Exposure				
HIKER	0.2849	15000	110	35
BERRY PICKER	0.8777	4900	34	11
HUNTER	0.3807	11000	79	26
FISHERMAN	0.3142	14000	95	32
RESIDENT	0.4059	11000	74	25

[a]The plus sign (+) means "greater than."

Table C-140
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Hexazinone

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.2503	6800	40	500
VEGETATION CONTACT				
HIKER	0.0036	470000	2800	35000
PICKER	0.6451	2600	16	190
DRINKING WATER	0.0880	19000	110	1400
EATING BERRIES	0.0699	24000	140	1800
EATING VEGETS.	0.1452	12000	69	860
EATING DEER	0.0157	110000	640	8000
EATING BIRD	0.0993	17000	100	1300
EATING FISH	0.0352	48000	280	3500
For Combined Routes of Exposure				
HIKER	0.3419	4900	29	370
BERRY PICKER	1.0533	1600	9.5	120
HUNTER	0.4568	3700	22	270
FISHERMAN	0.3771	4500	27	330
RESIDENT	0.4870	3500	21	260

Table C-141
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Picloram

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.0100	820000	700	5000
VEGETATION CONTACT				
HIKER	0.0001	1000000 +	49000	350000
PICKER	0.0258	320000	270	1900
DRINKING WATER	0.0734	110000	95	680
EATING BERRIES	0.0582	140000	120	860
EATING VEGETS.	0.1210	68000	58	410
EATING DEER	0.0118	700000	590	4200
EATING BIRD	0.0729	110000	96	690
EATING FISH	0.0293	280000	240	1700
For Combined Routes of Exposure:				
HIKER	0.0835	98000	84	600
BERRY PICKER	0.1674	49000	42	300
HUNTER	0.1682	49000	42	300
FISHERMAN	0.1129	73000	62	440
RESIDENT	0.2045	40000	34	240

[a]The plus sign (+) means "greater than."

Table C-142
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Simazine

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (5.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.2085	24000	24	24
VEGETATION CONTACT				
HIKER	0.0030	1000000 +	1700	1700
PICKER	0.5376	9300	9.3	9.3
DRINKING WATER	0.0734	68000	68	68
EATING BERRIES	0.0582	86000	86	86
EATING VEGETS.	0.1210	41000	41	41
EATING DEER	0.0131	380000	380	380
EATING BIRD	0.0827	60000	60	60
EATING FISH	0.0293	170000	170	170
For Combined Routes of Exposure				
HIKER	0.2849	18000	18	18
BERRY PICKER	0.8777	5700	5.7	5.7
HUNTER	0.3807	13000	13	13
FISHERMAN	0.3142	16000	16	16
RESIDENT	0.4059	12000	12	12

[a]The plus sign (+) means "greater than."

Table C-143
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Tebuthiuron

	EXPOSURE (MG/KG/DAY)	LD_{50} (644.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (12.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (90.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.2503	2600	50	360
VEGETATION CONTACT				
HIKER	0.0036	180000	3500	25000
PICKER	0.6451	1000	19	140
DRINKING WATER	0.0880	7300	140	1000
EATING BERRIES	0.0699	9200	180	1300
EATING VEGETS.	0.1452	4400	86	620
EATING DEER	0.0157	41000	800	5700
EATING BIRD	0.0993	6500	130	910
EATING FISH	0.3521	1800	35	260
For Combined Routes of Exposure				
HIKER	0.3419	1900	37	260
BERRY PICKER	1.0533	610	12	86
HUNTER	0.4568	1400	27	200
FISHERMAN	0.6940	930	18	130
RESIDENT	0.4870	1300	26	180

Table C-144
Margins of Safety for Exposed Members of the Public For Accidental-Worst Case Spraying with Triclopyr

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
For Single Route of Exposure				
DERMAL, SPRAY	0.3337	1900	7.5	30
VEGETATION CONTACT				
HIKER	0.0048	130000	520	2100
PICKER	0.8602	730	2.9	12
DRINKING WATER	0.1174	5400	21	85
EATING BERRIES	0.0932	6800	27	110
EATING VEGETS.	0.1935	3300	13	52
EATING DEER	0.0209	30000	120	480
EATING BIRD	0.1323	4800	19	76
EATING FISH	0.0470	13000	53	210
For Combined Routes of Exposure				
HIKER	0.4558	1400	5.5	22
BERRY PICKER	1.4044	450	1.8	7.1
HUNTER	0.6091	1000	4.1	16
FISHERMAN	0.5028	1300	5.0	20
RESIDENT	0.6494	970	3.8	15

Margins of Safety for Doses to Workers and the Public from Herbicide Spills

Table C-145
Margins of Safety for Doses Due to Spills of Amitrole Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (4080.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (0.03)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (5.00)
Spills onto Skin				
CONCENTRATE	1.2000	3400	-48	4.2
SPRAY MIX	0.2400	17000	-9.6	21
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.0737	55000	-2.9	68
RESERVOIR,HELO	0.0023	1000000 +	11	2200
POND, TRUCK	0.7365	5500	-29	6.8
RESERV.,TRUCK	0.0230	180000	1.1	220

[a]The plus sign (+) means "greater than."

Table C-146
Margins of Safety for Doses Due to Spills of Asulam Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (4000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (50.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
Spills onto Skin				
CONCENTRATE	240.0000	17	-4.8	-4.8
SPRAY MIX	20.0400	200	2.5	2.5
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.0615	65000	810	810
RESERVOIR,HELO	0.0019	1000000 +	26000	26000
POND, TRUCK	0.6150	6500	81	81
RESERV.,TRUCK	0.0192	210000	2600	2600

[a]The plus sign (+) means "greater than."

Table C-147
Margins of Safety for Doses Due to Spills of Atrazine Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (1869.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (3.70)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (100.00)
Spills onto Skin				
CONCENTRATE	240.0000	7.8	-65	-2.4
SPRAY MIX	24.0000	78	-6.5	4.2
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.0737	25000	50	1400
RESERVOIR,HELO	0.0023	810000	1600	43000
POND, TRUCK	0.7365	2500	5.0	140
RESERV.,TRUCK	0.0230	81000	160	4300

Table C-148
Margins of Safety for Doses Due to Spills of Bromacil Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (3998.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (6.25)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (7.92)
Spills onto Skin				
CONCENTRATE	240.0000	17	-38	-30
SPRAY MIX	12.0000	330	-1.9	-1.5
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	---	---	---	---
RESERVOIR,HELO	---	---	---	---
POND, TRUCK	0.3683	11000	17	22
RESERV.,TRUCK	0.0115	350000	540	690

Table C-149
Margins of Safety for Doses Due to Spills of 2,4-D Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (375.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (1.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (25.00)
Spills onto Skin				
CONCENTRATE	144.0000	2.6	-140	-5.8
SPRAY MIX	14.4000	26	-14	1.7
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.0737	5100	14	340
RESERVOIR,HELO	0.0023	160000	430	11000
POND, TRUCK	0.7365	510	1.4	34
RESERV.,TRUCK	0.0230	16000	43	1100

Table C-150
Margins of Safety for Doses Due to Spills of 2,4-DP Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (532.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (6.25)
Spills onto Skin				
CONCENTRATE	230.4000	2.3	-46	-37
SPRAY MIX	9.6000	55	-19	-1.5
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.0460	12000	110	140
RESERVOIR,HELO	0.0014	370000	3500	4300
POND, TRUCK	0.4603	1200	11	14
RESERV.,TRUCK	0.0144	37000	350	430

Table C-151
Margins of Safety for Doses Due to Spills of Dalapon Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (7577.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (15.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (300.00)
Spills onto Skin				
CONCENTRATE	---	---	---	---
SPRAY MIX	60.0000	130	-4.0	5.0
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.1841	41000	81	1600
RESERVOIR,HELO	0.0058	1000000 +	2600	52000
POND, TRUCK	1.8413	4100	8.1	160
RESERV.,TRUCK	0.0575	130000	260	5200

[a]The plus sign (+) means "greater than."

Table C-152
Margins of Safety for Doses Due to Spills of Dicamba Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (757.0)	MARGIN OF SAFETY RELATIVE TO: SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO: REPRODUCTIVE NOEL (2.50)
Spills onto Skin				
CONCENTRATE	120.0000	6.3	-4.8	-48
SPRAY MIX	12.0000	63	2.2	-4.8
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.0737	10000	340	34
RESERVOIR,HELO	0.0023	330000	11000	1100
POND, TRUCK	0.7365	1000	34	3.4
RESERV.,TRUCK	0.0230	33000	1000	110

Table C-153
Margins of Safety for Doses Due to Spills of Diuron Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (3750.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (9.63)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (6.25)
Spills onto Skin				
CONCENTRATE	240.0000	16	-380	-38
SPRAY MIX	19.2000	200	-31	-3.1
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO	---	---	---	---
RESERVOIR,HELO	---	---	---	---
POND, TRUCK	0.5892	6400	1.1	11
RESERV.,TRUCK	0.0184	200000	34	340

Table C-154
Margins of Safety for Doses Due to Spills of Fosamine Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (2440.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (25.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (750.00)
Spills onto Skin				
CONCENTRATE	240.0000	100	-9.6	3.1
SPRAY MIX	72.0000	340	-2.9	10
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.2210	110000	110	3400
RESERVOIR,HELO	0.0069	1000000 +	3600	110000
POND, TRUCK	2.2095	11000	11	340
RESERV.,TRUCK	0.0690	350000	360	11000

[a]The plus sign (+) means "greater than."

Table C-155
Margins of Safety for Doses Due to Spills of Glyphosate Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (4320.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (30.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
Spills onto Skin				
CONCENTRATE	180.0000	24	-6.0	-1.8
SPRAY MIX	30.0000	140	-1.0	-3.0
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.0921	47000	330	110
RESERVOIR,HELO	0.0029	1000000 +	10000	3500
POND, TRUCK	0.9206	4700	33	11
RESERV.,TRUCK	0.0288	150000	1000	350

[a]The plus sign (+) means "greater than."

Table C-156
Margins of Safety for Doses Due to Spills of Hexazinone Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (1690.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (10.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (125.00)
Spills onto Skin				
CONCENTRATE	120.0000	14	-12	1.0
SPRAY MIX	18.0000	94	-1.8	6.9
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO,	0.0552	31000	180	2300
RESERVOIR,HELO	0.0017	980000	5900	72000
POND, TRUCK	0.5524	3100	18	230
RESERV.,TRUCK	0.0173	98000	580	7200

Table C-157
Margins of Safety for Doses Due to Spills of Picloram For Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (8200.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (7.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (50.00)
Spills onto Skin				
CONCENTRATE	5.7600	1400	1.2	8.7
SPRAY MIX	1.4400	5700	4.9	35
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.0921	89000	76	540
RESERVOIR,HELO	0.0029	1000000+	2400	17000
POND, TRUCK	0.9206	8900	7.6	54
RESERV.,TRUCK	0.0288	290000	240	1700

[a]The plus sign (+) means "greater than."

Table C-158
Margins of Safety for Doses Due to Spills of Simazine For Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (5000.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (5.00)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (5.00)
Spills onto Skin				
CONCENTRATE	240.0000	21	-48	-48
SPRAY MIX	30.0000	170	-6.0	-6.0
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.0921	54000	54	54
RESERVOIR,HELO	0.0029	1000000+	1700	1700
POND, TRUCK	0.9206	5400	5.4	5.4
RESERV.,TRUCK	0.0288	170000	170	170

[a]The plus sign (+) means "greater than."

Table C-159
Margins of Safety for Doses Due to Spills of Tebuthiuron For Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (644.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (12.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (90.00)
Spills onto Skin				
CONCENTRATE	---	---	---	---
SPRAY MIX	36.0000	18	-2.9	2.5
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.1105	5800	110	810
RESERVOIR,HELO	0.0035	190000	3600	26000
POND, TRUCK	1.1048	580	11	81
RESERV.,TRUCK	0.0345	19000	360	2600

Table C-160
Margins of Safety for Doses Due to Spills of Triclopyr For Accidental-Worst Case Scenario

	EXPOSURE (MG/KG/DAY)	LD_{50} (630.0)	MARGIN OF SAFETY RELATIVE TO SYSTEMIC NOEL (2.50)	MARGIN OF SAFETY RELATIVE TO REPRODUCTIVE NOEL (10.00)
Spills onto Skin				
CONCENTRATE	240.0000	2.6	-96	-24
SPRAY MIX	48.0000	13	-19	-4.8
Spills Into Bodies of Water (Drinking One Liter of Water)				
POND, HELO.	0.1473	4300	17	68
RESERVOIR,HELO	0.0046	140000	540	2200
POND, TRUCK	1.4730	430	1.7	6.8
RESERV.,TRUCK	0.0460	14000	54	220

Table C-161
Lifetime Cancer Risk - Exposed Public For Small Backpack, 6.0 Acres, Routine-Realistic Scenario

	EXPOSURES PER LIFETIME	RISK FROM EXCLUSIVE USE OF: 2,4-D	2,4-DP	ASULAM	BROMACIL	PICLORAM	AMITROLE	GLYPHOSATE
FOR A SINGLE EXPOSURE								
DERMAL, SPRAY	1	1.09E-10	1.36E-09	2.10E-11	5.29E-11	4.94E-13	5.01E-10	1.61E-12
VEGETATION CONTACT								
HIKER	1	1.57E-12	1.96E-11	3.02E-13	7.60E-13	7.09E-15	7.19E-12	2.31E-14
PICKER	1	4.33E-10	5.40E-09	8.32E-11	2.10E-10	1.95E-12	1.98E-09	6.39E-12
DRINKING WATER	1	1.70E-10	1.98E-09	1.96E-11	4.93E-11	9.59E-12	4.67E-08	1.50E-12
EATING BERRIES	1	3.13E-10	3.66E-09	3.61E-11	9.10E-11	1.77E-11	8.61E-08	2.77E-12
EATING VEGETS.	1	6.26E-10	7.32E-09	7.23E-11	1.82E-10	3.54E-11	1.72E-07	5.55E-12
EATING DEER	1	4.01E-11	4.69E-10	4.71E-12	1.18E-11	2.20E-12	1.07E-08	3.61E-13
EATING FISH	1	6.79E-11	7.94E-10	7.84E-12	1.97E-11	3.83E-12	1.87E-08	6.01E-13
Combined Routes of Exposure								
HIKER	1	2.81E-10	3.37E-09	4.09E-11	1.03E-10	1.01E-11	4.72E-08	3.14E-12
BERRY PICKER	1	1.03E-09	1.24E-08	1.80E-10	4.03E-10	2.97E-11	1.35E-07	1.23E-11
HUNTER	1	4.41E-10	5.24E-09	6.01E-11	1.51E-10	1.86E-11	8.86E-08	4.61E-12
FISHERMAN	1	3.49E-10	4.16E-09	4.88E-11	1.23E-10	1.39E-11	6.59E-08	3.74E-12
RESIDENT	1	9.07E-10	1.07E-08	1.13E-10	2.85E-10	4.55E-11	2.19E-07	8.68E-12
FOR 30 EXPOSURES								
DERMAL, SPRAY	30	3.28E-09	4.09E-08	6.31E-10	1.59E-09	1.48E-11	1.50E-08	4.84E-11
VEGETATION CONTACT								
HIKER	30	4.71E-11	5.87E-10	9.05E-12	2.28E-11	2.13E-13	2.16E-10	6.94E-13
PICKER	30	1.30E-08	1.62E-07	2.50E-09	6.29E-09	5.86E-11	5.95E-08	1.92E-10
DRINKING WATER	30	5.09E-09	5.95E-08	5.88E-10	1.48E-09	2.88E-10	1.40E-06	4.51E-11
EATING BERRIES	30	9.40E-09	1.10E-07	1.08E-09	2.73E-09	5.31E-10	2.58E-06	8.32E-11
EATING VEGETS.	30	1.88E-08	2.20E-07	2.17E-09	5.46E-09	1.06E-09	5.17E-06	1.66E-10
EATING DEER	30	1.20E-09	1.41E-08	1.41E-10	3.55E-10	6.61E-11	3.22E-07	1.08E-11
EATING FISH	30	2.04E-09	2.38E-08	2.35E-10	5.92E-10	1.15E-10	5.60E-07	1.80E-11
Combined Routes of Exposure								
HIKER	30	8.42E-09	1.01E-07	1.23E-09	3.09E-09	3.03E-10	1.42E-06	9.42E-11
BERRY PICKER	30	3.08E-08	3.72E-07	4.80E-09	1.21E-08	8.92E-10	4.06E-06	3.68E-10
HUNTER	30	1.32E-08	1.57E-07	1.80E-09	4.54E-09	5.59E-10	2.66E-06	1.38E-10
FISHERMAN	30	1.05E-08	1.25E-07	1.46E-09	3.68E-09	4.18E-10	1.98E-06	1.12E-10
RESIDENT	30	2.72E-08	3.21E-07	3.40E-09	8.55E-09	1.36E-09	6.58E-06	2.61E-10

Table C-162
Lifetime Cancer Risk - Exposed Public For Large Backpack, 60 Acres, Routine-Worst Case

	EXPOSURES PER LIFETIME	RISK FROM EXCLUSIVE USE OF: 2,4-D	2,4-DP	ASULAM	BROMACIL	PICLORAM	AMITROLE	GLYPHOSATE
FOR A SINGLE EXPOSURE								
DERMAL, SPRAY VEGETATION CONTACT	1	4.21E-10	5.64E-09	1.13E-10	2.55E-10	3.80E-12	2.41E-09	1.03E-11
HIKER	1	6.04E-12	8.09E-11	1.62E-12	3.66E-12	5.45E-14	3.46E-11	1.48E-13
PICKER	1	1.08E-09	1.45E-08	2.90E-10	6.57E-10	9.80E-12	6.21E-09	2.67E-11
DRINKING WATER	1	3.91E-10	4.91E-09	6.28E-11	1.42E-10	4.42E-11	1.34E-07	5.77E-12
EATING BERRIES	1	7.55E-10	9.49E-09	1.21E-10	2.74E-10	8.52E-11	2.59E-07	1.11E-11
EATING VEGETS.	1	1.51E-09	1.90E-08	2.42E-10	5.48E-10	1.70E-10	5.19E-07	2.23E-11
EATING DEER	1	9.73E-11	1.22E-09	1.59E-11	3.60E-11	1.07E-11	3.25E-08	1.46E-12
EATING FISH	1	1.56E-10	1.97E-09	2.51E-11	5.68E-11	1.77E-11	5.38E-08	2.31E-12
Combined Routes of Exposure								
HIKER	1	8.18E-10	1.06E-08	1.77E-10	4.00E-10	4.80E-11	1.37E-07	1.63E-11
BERRY PICKER	1	2.65E-09	3.46E-08	5.87E-10	1.33E-09	1.43E-10	4.02E-07	5.39E-11
HUNTER	1	1.21E-09	1.56E-08	2.43E-10	5.50E-10	9.02E-11	2.65E-07	2.23E-11
FISHERMAN	1	9.74E-10	1.26E-08	2.02E-10	4.57E-10	6.57E-11	1.91E-07	1.86E-11
RESIDENT	1	2.33E-09	2.96E-08	4.19E-10	9.49E-10	2.18E-10	6.56E-07	3.85E-11
FOR 30 EXPOSURES								
DERMAL, SPRAY VEGETATION CONTACT	30	1.26E-08	1.69E-07	3.38E-09	7.64E-10	1.14E-10	7.23E-08	3.10E-10
HIKER	30	1.81E-10	2.43E-09	4.85E-11	1.10E-10	1.64E-12	1.04E-09	4.45E-12
PICKER	30	3.25E-08	4.36E-07	8.71E-09	1.97E-08	2.94E-10	1.86E-07	8.00E-10
DRINKING WATER	30	1.17E-08	1.47E-07	1.88E-09	4.26E-09	1.32E-09	4.03E-06	1.73E-10
EATING BERRIES	30	2.26E-08	2.85E-07	3.64E-09	8.22E-09	2.56E-09	7.78E-06	3.34E-10
EATING VEGETS.	30	4.53E-08	5.69E-07	7.27E-09	1.64E-08	5.11E-09	1.56E-05	6.68E-10
EATING DEER	30	2.92E-09	3.67E-08	4.77E-10	1.08E-09	3.21E-10	9.75E-07	4.39E-11
EATING FISH	30	4.69E-09	5.90E-08	7.54E-10	1.70E-09	5.30E-10	1.61E-06	6.92E-11
Combined Routes of Exposure								
HIKER	30	2.45E-08	3.19E-07	5.31E-09	1.20E-08	1.44E-09	4.11E-06	4.88E-10
BERRY PICKER	30	7.96E-08	1.04E-06	1.76E-08	3.98E-08	4.29E-09	1.21E-05	1.62E-09
HUNTER	30	3.64E-08	4.69E-07	7.29E-09	1.65E-08	2.71E-09	7.95E-06	6.70E-10
FISHERMAN	30	2.92E-08	3.78E-07	6.07E-09	1.37E-08	1.97E-09	5.72E-06	5.57E-10
RESIDENT	30	6.98E-08	8.88E-07	1.26E-08	2.85E-08	6.55E-09	1.97E-05	1.16E-09

Table C-163
Lifetime Cancer Risk - Exposed Public For Small Right of Way, Routine-Realistic Scenario

	EXPOSURES PER LIFETIME	RISK FROM EXCLUSIVE USE OF: 2,4-D	2,4-DP	ASULAM	BROMACIL	PICLORAM	AMITROLE	GLYPHOSATE
FOR A SINGLE EXPOSURE								
DERMAL, SPRAY	1	2.65E-11	3.30E-10	8.15E-12	1.03E-11	9.57E-14	9.71E-11	4.17E-13
VEGETATION CONTACT								
HIKER	1	3.80E-13	4.74E-12	1.17E-13	1.47E-13	1.37E-15	1.39E-12	5.98E-15
PICKER	1	1.43E-10	1.79E-09	4.41E-11	5.55E-11	5.18E-13	5.25E-10	2.25E-12
DRINKING WATER	1	9.52E-11	1.11E-09	1.76E-11	2.21E-11	4.30E-12	2.09E-08	8.99E-13
EATING BERRIES	1	1.31E-10	1.53E-09	2.42E-11	3.04E-11	5.91E-12	2.88E-08	1.24E-12
EATING VEGETS.	1	2.62E-10	3.06E-09	4.83E-11	6.08E-11	1.18E-11	5.76E-08	2.47E-12
EATING DEER	1	1.61E-11	1.88E-10	3.01E-12	3.79E-12	7.10E-13	3.45E-09	1.54E-13
EATING FISH	1	3.81E-11	4.45E-10	7.03E-12	8.85E-12	1.72E-12	8.38E-09	3.60E-13
Combined Routes of Exposure								
HIKER	1	1.22E-10	1.45E-09	2.58E-11	3.25E-11	4.40E-12	2.10E-08	1.32E-12
BERRY PICKER	1	3.96E-10	4.76E-09	9.40E-11	1.18E-10	1.08E-11	5.03E-08	4.81E-12
HUNTER	1	1.80E-10	2.12E-09	3.68E-11	4.64E-11	6.87E-12	3.30E-08	1.88E-12
FISHERMAN	1	1.60E-10	1.89E-09	3.29E-11	4.14E-11	6.12E-12	2.94E-08	1.68E-12
RESIDENT	1	3.84E-10	4.51E-09	7.41E-11	9.34E-11	1.62E-11	7.86E-08	3.79E-12
FOR 30 EXPOSURES								
DERMAL, SPRAY	30	7.94E-10	9.90E-09	2.44E-10	3.08E-10	2.87E-12	2.91E-09	1.25E-11
VEGETATION CONTACT								
HIKER	30	1.14E-11	1.42E-10	3.51E-12	4.41E-12	4.12E-14	4.18E-11	1.79E-13
PICKER	30	4.30E-09	5.36E-08	1.32E-09	1.67E-09	1.55E-11	1.58E-08	6.76E-11
DRINKING WATER	30	2.86E-09	3.34E-08	5.27E-10	6.64E-10	1.29E-10	6.28E-07	2.70E-11
EATING BERRIES	30	3.92E-09	4.59E-08	7.25E-10	9.12E-10	1.77E-10	8.63E-07	3.71E-11
EATING VEGETS.	30	7.85E-09	9.18E-08	1.45E-09	1.82E-09	3.55E-10	1.73E-06	7.41E-11
EATING DEER	30	4.82E-10	5.64E-09	9.03E-11	1.14E-10	2.13E-11	1.04E-07	4.62E-12
EATING FISH	30	1.14E-09	1.34E-08	2.11E-10	2.66E-10	5.16E-11	2.51E-07	1.08E-11
Combined Routes of Exposure								
HIKER	30	3.66E-09	4.34E-08	7.75E-10	9.76E-10	1.32E-10	6.31E-07	3.96E-11
BERRY PICKER	30	1.19E-08	1.43E-07	2.82E-09	3.55E-09	3.25E-10	1.51E-06	1.44E-10
HUNTER	30	5.39E-09	6.37E-08	1.11E-09	1.39E-09	2.06E-10	9.91E-07	5.65E-11
FISHERMAN	30	4.80E-09	5.68E-08	9.86E-10	1.24E-09	1.84E-10	8.83E-07	5.04E-11
RESIDENT	30	1.15E-08	1.35E-07	2.22E-09	2.80E-09	4.87E-10	2.36E-06	1.14E-10

Table C-164
Lifetime Cancer Risk - Exposed Public For Large Right of Way, Routine-Worst Case

	EXPOSURES PER LIFETIME	RISK FROM EXCLUSIVE USE OF: 2,4-D	2,4-DP	ASULAM	BROMACIL	PICLORAM	AMITROLE	GLYPHOSATE
FOR A SINGLE EXPOSURE								
DERMAL, SPRAY	1	1.51E-10	2.30E-09	5.90E-11	8.92E-11	6.65E-13	1.35E-09	3.62E-12
VEGETATION CONTACT								
HIKER	1	2.17E-12	3.29E-11	8.47E-13	1.28E-12	9.55E-15	1.94E-11	5.20E-14
PICKER	1	3.89E-10	5.92E-09	1.52E-10	2.30E-10	1.72E-12	3.48E-09	9.34E-12
DRINKING WATER	1	2.09E-10	2.98E-09	4.90E-11	7.40E-11	1.15E-11	1.12E-07	3.01E-12
EATING BERRIES	1	3.25E-10	4.64E-09	7.63E-11	1.15E-10	1.79E-11	1.75E-07	4.68E-12
EATING VEGETS.	1	6.51E-10	9.28E-09	1.53E-10	2.31E-10	3.58E-11	3.49E-07	9.37E-12
EATING DEER	1	4.05E-11	5.78E-10	9.65E-12	1.46E-11	2.18E-12	2.12E-08	5.92E-13
EATING FISH	1	8.36E-11	1.19E-09	1.96E-11	2.96E-11	4.60E-12	4.48E-08	1.20E-12
Combined Routes of Exposure								
HIKER	1	3.62E-10	5.31E-09	1.09E-10	1.64E-10	1.22E-11	1.13E-07	6.68E-12
BERRY PICKER	1	1.07E-09	1.58E-08	3.36E-10	5.08E-10	3.18E-11	2.91E-07	2.06E-11
HUNTER	1	5.13E-10	7.47E-09	1.46E-10	2.20E-10	2.01E-11	1.90E-07	8.94E-12
FISHERMAN	1	4.46E-10	6.50E-09	1.28E-10	1.94E-10	1.68E-11	1.58E-07	7.88E-12
RESIDENT	1	1.01E-09	1.46E-08	2.61E-10	3.95E-10	4.80E-11	4.63E-07	1.60E-11
FOR 30 EXPOSURES								
DERMAL, SPRAY	30	4.53E-09	6.89E-08	1.77E-09	2.68E-09	2.00E-11	4.05E-08	1.09E-10
VEGETATION CONTACT								
HIKER	30	6.50E-11	9.88E-10	2.54E-11	3.84E-11	2.86E-13	5.81E-10	1.56E-12
PICKER	30	1.17E-08	1.78E-07	4.56E-09	6.90E-09	5.15E-11	1.04E-07	2.80E-10
DRINKING WATER	30	6.27E-09	8.94E-08	1.47E-09	2.22E-09	3.45E-10	3.36E-06	9.02E-11
EATING BERRIES	30	9.76E-09	1.39E-07	2.29E-09	3.46E-09	5.38E-10	5.24E-06	1.40E-10
EATING VEGETS.	30	1.95E-08	2.78E-07	4.58E-09	6.92E-09	1.08E-09	1.05E-05	2.81E-10
EATING DEER	30	1.22E-09	1.74E-08	2.90E-10	4.38E-10	6.55E-11	6.36E-07	1.78E-11
EATING FISH	30	2.51E-09	3.57E-08	5.88E-10	8.88E-10	1.38E-10	1.35E-06	3.61E-11
Combined Routes of Exposure								
HIKER	30	1.09E-08	1.59E-07	3.27E-09	4.93E-09	3.66E-10	3.40E-06	2.00E-10
BERRY PICKER	30	3.22E-08	4.75E-07	1.01E-08	1.53E-08	9.54E-10	8.74E-06	6.19E-10
HUNTER	30	1.54E-08	2.24E-07	4.37E-09	6.60E-09	6.03E-10	5.70E-06	2.68E-10
FISHERMAN	30	1.34E-08	1.95E-07	3.85E-09	5.82E-09	5.04E-10	4.75E-06	2.37E-10
RESIDENT	30	3.04E-08	4.38E-07	7.84E-09	1.19E-08	1.44E-09	1.39E-05	4.81E-10

Table C-165
Lifetime Cancer Risk - Exposed Public For Accidental-Worst Case Spraying

	EXPOSURES PER LIFETIME	RISK FROM EXCLUSIVE USE OF: 2,4-D	2,4-DP	ASULAM	BROMACIL	PICLORAM	AMITROLE	GLYPHOSATE
FOR A SINGLE EXPOSURE								
DERMAL, SPRAY	1	1.05E-07	1.60E-06	4.11E-08	6.20E-08	1.16E-09	9.39E-07	2.52E-09
VEGETATION CONTACT								
HIKER	1	1.51E-09	2.29E-08	5.89E-10	8.90E-10	1.66E-11	1.35E-08	3.61E-11
PICKER	1	2.71E-07	4.12E-06	1.06E-07	1.60E-07	2.98E-09	2.42E-06	6.50E-09
DRINKING WATER	1	6.16E-08	8.78E-07	1.44E-08	2.18E-08	8.48E-09	3.30E-05	8.86E-10
EATING BERRIES	1	4.89E-08	6.97E-07	1.15E-08	1.73E-08	6.73E-09	2.62E-05	7.04E-10
EATING VEGETS.	1	1.02E-07	1.45E-06	2.38E-08	3.60E-08	1.40E-08	5.45E-05	1.46E-09
EATING DEER	1	1.05E-08	1.50E-07	2.57E-09	3.88E-09	1.36E-09	5.28E-06	1.58E-10
EATING FISH	1	2.46E-08	3.51E-07	5.78E-09	8.73E-09	3.39E-09	1.32E-05	3.55E-10
Combined Routes of Exposure								
HIKER	1	1.68E-07	2.50E-06	5.61E-08	8.47E-08	9.65E-09	3.40E-05	3.44E-09
BERRY PICKER	1	4.86E-07	7.29E-06	1.73E-07	2.61E-07	1.94E-08	6.26E-05	1.06E-08
HUNTER	1	2.45E-07	3.59E-06	7.49E-08	1.13E-07	1.94E-08	7.19E-05	4.60E-09
FISHERMAN	1	1.93E-07	2.85E-06	6.19E-08	9.35E-08	1.30E-08	4.72E-05	3.80E-09
RESIDENT	1	2.70E-07	3.95E-06	7.99E-08	1.21E-07	2.36E-08	8.85E-05	4.90E-09
FOR 30 EXPOSURES								
DERMAL, SPRAY	30	3.15E-06	4.79E-05	1.23E-06	1.86E-06	3.47E-08	2.82E-05	7.56E-08
VEGETATION CONTACT								
HIKER	30	4.52E-08	6.87E-07	1.77E-08	2.67E-08	4.98E-10	4.04E-07	1.08E-09
PICKER	30	8.12E-06	1.24E-04	3.18E-06	4.80E-06	8.95E-08	7.26E-05	1.95E-07
DRINKING WATER	30	1.85E-06	2.63E-05	4.33E-07	6.55E-07	2.54E-07	9.91E-04	2.66E-08
EATING BERRIES	30	1.47E-06	2.09E-05	3.44E-07	5.20E-07	2.02E-07	7.87E-04	2.11E-08
EATING VEGETS.	30	3.05E-06	4.34E-05	7.14E-07	1.08E-06	4.19E-07	1.63E-03	4.38E-08
EATING DEER	30	3.15E-07	4.51E-06	7.71E-08	1.16E-07	4.08E-08	1.58E-04	4.73E-09
EATING FISH	30	7.39E-07	1.05E-05	1.73E-07	2.62E-07	1.02E-07	3.96E-04	1.06E-08
Combined Routes of Exposure								
HIKER	30	5.04E-06	7.49E-05	1.68E-06	2.54E-06	2.90E-07	1.02E-03	1.03E-07
BERRY PICKER	30	1.46E-05	2.19E-04	5.18E-06	7.83E-06	5.81E-07	1.88E-03	3.18E-07
HUNTER	30	7.34E-06	1.08E-04	2.25E-06	3.40E-06	5.83E-07	2.16E-03	1.38E-07
FISHERMAN	30	5.78E-06	8.55E-05	1.86E-06	2.80E-06	3.91E-07	1.42E-03	1.14E-07
RESIDENT	30	8.09E-06	1.18E-04	2.40E-06	3.62E-06	7.09E-07	2.65E-03	1.47E-07

Table C-166
Lifetime Cancer Risk - Exposure Due to Spills

	EXPOSURES PER LIFETIME	RISK FROM EXCLUSIVE USE OF: 2,4-D	2,4-DP	ASULAM	BROMACIL	PICLORAM	AMITROLE	GLYPHOSATE
FOR A SINGLE EXPOSURE								
SPILLS ONTO SKIN								
CONCENTRATE	1	1.47E-04	2.75E-03	4.72E-05	3.57E-05	6.66E-07	3.38E-04	2.17E-06
SPRAY MIX	1	1.47E-05	1.15E-04	3.95E-06	1.78E-06	1.66E-07	6.76E-05	3.62E-07
SPILLS INTO WATER (1 LITER DRUNK)								
POND, HELO.	1	7.54E-08	5.51E-07	1.21E-08	----	1.06E-08	2.07E-05	1.11E-09
RESERV., HELO.	1	2.36E-09	1.72E-08	3.78E-10	----	3.33E-10	6.48E-07	3.48E-11
POND, TRUCK	1	7.54E-07	5.51E-06	1.21E-07	----	1.06E-07	2.07E-04	1.11E-08
RESERV., TRUCK	1	2.36E-08	1.72E-07	3.78E-09	1.71E-09	3.33E-09	6.48E-06	3.48E-10

Appendix M
Toxicity Research Costs

Council on Environmental Quality regulations (40 CFR 1502.22) require that gaps in relevant information or scientific uncertainty be included in an EIS unless the cost of obtaining such information is exorbitant. It would be virtually impossible for BLM with its limited resources to conduct the research on toxicity of herbicides needed to answer the questions that have arisen either from data gaps or scientific discord. Neither 2,4-D nor picloram has been shown to be a potent carcinogen. To identify a sample population large enough to differentiate between cancer induced by exposure to these herbicides and cancer caused by exposure to other environmental, factors such as diet, polluted air, drinking water, or predisposition by other natural factors, would be a prohibitatively time consuming (3-5 years) and costly process. The cost exorbitance of such research is shown in Table M-1. In response to existing data gaps on 2,4-D and picloram, registrants are conducting research. On the basis the costs of filling the research gaps identified for the program level, the cost of filling the data gaps has been determined to be exorbitant unless a worst-case analysis finds a substantive risk of cancer.

Estimated Costs of Research to Fill Data Gaps or to Resolve Scientific Uncertainties Pertaining to 2,4-D, Picloram, Glyphosate, and Asulam

Test	Cost Estimate($)[1] 1984	2,4-D	Picloram	Glyphosate	Asulam
Acute Toxicity (including dermal, inhalation and oral in guinea pigs and dogs	110,000	●	●		
Subchronic Toxicity (including dermal, inhalation, and oral in rats, dogs, and rabbits.)	525,254		●	●	●
Chronic Toxicity (three-phase tests in rats and dogs)	1,685,165	●	●	●	●
Oncogenicity (three-phase tests in rats and mice)	1,576,186	●	●	●	●
Teratogenicity (three-phase tests in rats and rabbits)	129,760	●	●		
Mutagenicity (including Ames test, mutation assays, sex-linked lethal assays, somatic cell mutations, and locus gene mutations)	36,131		●		
Chromosomal Effects (including cytogenetics, heritable translocations, and unscheduled DNA synthesis)	110,000		●	●	●
Total	4,172,496	3,501,111	4,172,496	3,896,605	3,896,605

[1]Based on Centaur Associates estimates from 1980 to 1982 and updated using the Consumer Price Index.

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